Industrial Sectors Market Characterization

Mineral Product Manufacturing Industry

Developed for

Pacific Gas & Electric Company and

Southern California Edison Company

Oakland, California, January 2012

Experience you can trust.

Table of Contents

Table of Contents

List of Figures

Table of Contents

List of Tables

Table of Contents

Acronyms and Abbreviations

AB 32	Assembly Bill 32 the Global Warming Solutions Act
ACEEE	American Council for an Energy Efficiency Economy
ACerS	American Ceramics Society
ACELA	American Clean Energy Leadership Act of 2009
ACES	American Clean Energy and Security Act of 2009
AMO	Advanced Manufacturing Office
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ARB	California Air Resources Board
BIA	Brick Industry Association
BPS	Ballistic Protection System
BSI	Building Stone Institute
Btu	British thermal unit
CAA	Clean Air Act
CAD	computer-aided design
CAM	computer-aided manufacturing
CEI	continual energy improvement
CHP	combined heat and power
CLC	Chemical Lime Corporation
CWA	Clean Water Act
CO_2	carbon dioxide
CO_2e	carbon-dioxide equivalent
EEPS	energy efficiency portfolio standards
EITE	Energy-intensive trade exposed
ESA	Endangered Species Act
GHG	greenhouse gas
GWh	gigawatt-hour(s)

Table of Contents

HPGR	high-pressure grinding roll
IAC	Industrial Assessment Center
ICT	information and communications technology
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
MIA	Marble Institute of America
NAICS	North American Industry Classification System
NGC	National Gypsum Corporation
NLA	National Lime Association
NSSGA	National Sand, Stone , and Gravel Association
O&M	operations and maintenance
PG&E	Pacific Gas and Electric Company
PSI	pounds per square inch
PVC	polyvinyl chloride
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RPS	renewable portfolio standard
SCE	Southern California Edison Company
SEP	superior energy performance
TBtu	trillion British thermal unit
U.S.	United States
USGS	U.S. Geological Survey
U.S. EPA	U.S. Environmental Protection Agency
U.S. DOE	U.S. Department of Energy
VFD	variable frequency drive

Table of Contents

Summary of Findings

Mineral products manufacturing (North American Industry Classification System prefixes 3271, 3274, 3279) consists of just over a dozen relatively small product segments which utilize the useful properties of common earth materials. Most mineral products are produced for the construction industry, although a few mineral products have more diverse markets. With around $24 billion in annual United States (U.S.) sales, the industry encompasses a diverse set of manufacturers which develop products in clay, brick, ceramic, lime, gypsum, stone, slate, and other products. Lime, gypsum, and clay manufacturers dominate nationally, with many more focused firms producing products ranging from porcelain fixtures to advanced aerospace ceramics. Gypsum and various clay manufacturers are prominent throughout California, and northern California has some prominent lime manufacturers while southern California has notable advanced ceramics makers.

Industry Landscape and Operational Models

Mineral products tend to have a low-value to weight ratio and most mineral product customers require uniform quality and timely delivery. These central imperatives favor a regional production and distribution model that has evolved to favor local operating subsidiaries owned by global conglomerates.

There are two prominent business models which cover much of the industry: vertical integrated and specialty producer. The cost structure spans a wide range—for instance, gypsum makers are relatively capital intensive; lime makers are energy intensive; and brick makers are labor intensive. Regardless of the breakdown of manufacturing costs, most businesses produce large physical volumes of low-value products and must efficiently distribute them, leading to distribution networks which minimize distance and have redundancy. Advanced ceramics makers and artisan building product makers are exceptions, adding significant value through technical expertise, craftsmanship, customization, and/or delivering products which meet exceptionally detailed specifications.

Energy Use

Innovation in mineral manufacturing focuses on new and improved products, rather than process efficiency, as a means of differentiation is the main industry sustainability focus. The goal of new manufacturing technology is usually to improve production flexibility and lower costs without compromising the downstream supply chain. The ability to scale is critical, because most operations are substantial simply due to the mass of material being processed.

Across the mineral products industry, energy use reflects the amount of heating and kiln operations, as well as machine drives. Crushed and cut stone manufacturers use comparatively little energy, brick manufacturers use more, gypsum makers use more still (as natural gas) and lime manufacturers the most (as coal). The industry as a whole consumes 250 to 300 million British thermal units (Btu) annually, with kiln operations and heating claiming the bulk of usage.

Drivers for Energy Decision Making

Across the market, new technology must not compromise the ability to consistently deliver products on specification and on time. Despite the trend to highlight sustainability attributes in marketing, there is little motivation either from regulations, or market pressures, to achieve manufacturing process energy efficiency. New regulatory obligations under California AB 32 will impact only the largest manufacturers.

Moving forward, kilns and process heat unit operations offer the largest opportunity for energy efficiency. Although the replacement cost is prohibitive for energy efficiency gains alone, measures that address optimizing operations such as variable frequency drives (VFD) on kiln fans are relevant. Subsectors that rely on kilns with potential high impact include gypsum, clay products, and lime. Some subsectors like vitreous china manufacturing and cut stone manufacturing are small and diffuse, making them challenging targets for substantial overall impact. The most effective ways to achieve energy reductions among subsectors which are not heavily concentrated include adopting automation and control; incremental energy efficiency retrofits, and focusing on best practices for energy efficiency in manufacturing.

Overall Findings

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

- Short payback projects are highly desirable in the minerals sector. Given the economic downturn, 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.
- Emphasizing the energy efficiency attributes of new products such as cool-roof tiles is likely to resonate with mineral product manufacturers and downstream consumers alike.

These customers are unlikely to pursue projects for energy efficiency gains alone, but will readily accept more efficient options when available.

- Many, but not all, major energy consumers have already implemented efficiency gains with the highest return on investment. Available energy efficiency opportunities in the minerals sector are likely to be modest, with kiln and heating technologies the best targets for marginal efficiency gains.
- Smaller players may benefit particularly from enhanced automation and control, which can help enable more efficient belts, dust collection, and grinding, as well as heating.
- New technologies are available, but this sector is risk averse and is slow to innovate to new processes. Innovation is more likely in product development.

Additional communication would be well received by minerals sector customers. Because the minerals industry is comprised of numerous smaller manufacturers engaged in a variety of different subsectors, reaching each customer individually is difficult. Increasing established approaches such as email, workshops, forums, and newsletters can bridge the knowledge gap in program understanding.

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 the next phase to prepare market intelligence on seven key energy-intensive sub-segments.

The research objective is to 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)
- Attachments with the interview and forum guides
- Utility-specific appendices containing proprietary data and customer information and analysis (Appendix A-E).

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

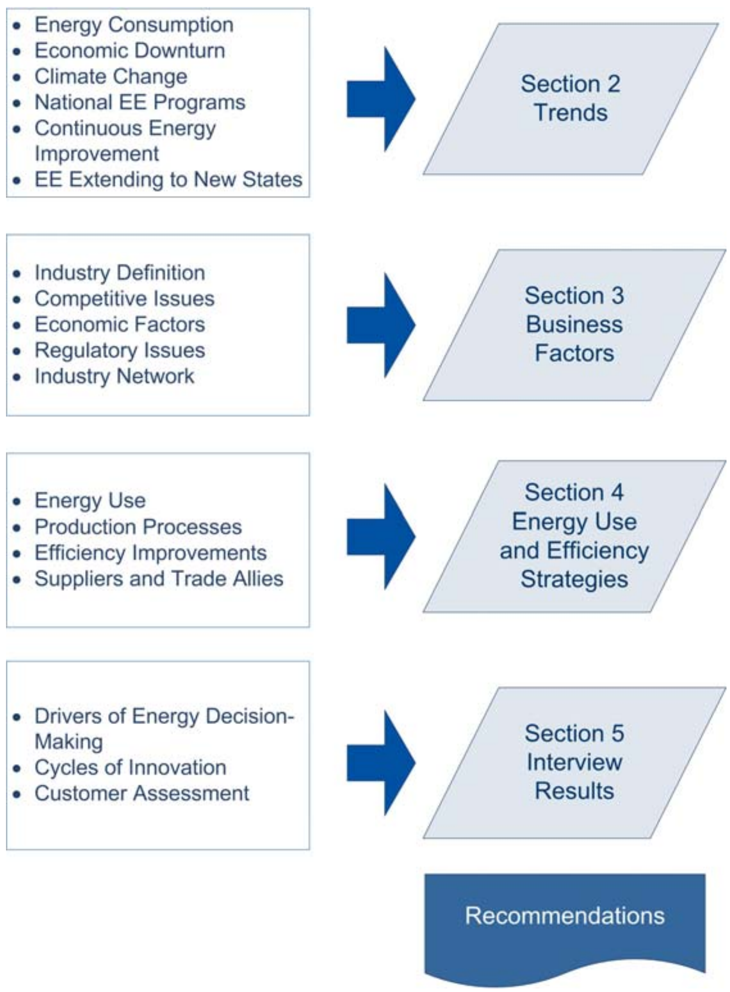
[1] Quinn, Jim. 2009. *Introduction to the Industrial Technologies Program*. Save Energy Now Series Webinar. January 15.
http://www1.eere.energy.gov/industry/pdfs/webcast_2009-0115_introtoitp.PDF

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

roundtable discussions. The outcome is a thorough research report intended to provide PG&E 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 provides a graphic overview of the report.

Figure 1: Graphic Overview of the Report



2. National Trends in Industrial Energy Efficiency

2.1 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 at 20 percent or more nationally 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; the rise of continual energy improvement; energy efficiency adoption outside California and national energy efficiency programs. These trends are discussed in more detail below.

2.2 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]

---

[3] Ibid.

[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

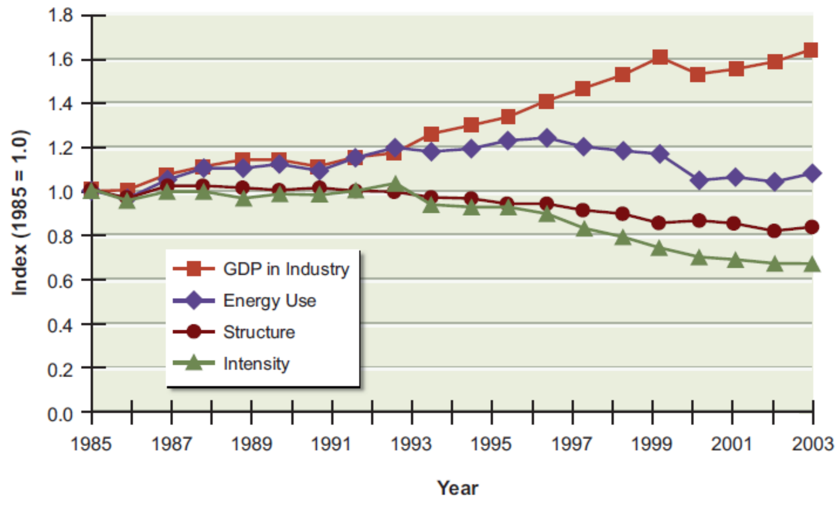
Source: Energy Information Administration[6]

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. Department of Energy. 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. 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]

2.3 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 California, industries that serve the housing and construction market, such as minerals, have been particularly affected. For example, gypsum production in the United States fell from 21,100 tons in 2006 to 9,000 tons in 2010.[9] Gypsum is required for wallboard. California is the third-ranking state for gypsum production, following Nevada and Iowa.

A 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,

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

[9] U.S. Geological Survey. 2011. Mineral Commodity Summaries, Gypsum. Reston, Virginia. January 21, 2011. http://minerals.usgs.gov/minerals/pubs/commodity/gypsum/mcs-2011-gypsu.PDF

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[10]

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) Advance Manufacturing Office (AMO) and through increased energy management systems, as discussed in the following sections.

2.4 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 3. This reduction is largely attributable to U.S. industry's net decrease in energy consumption, according to the American Council for an Energy Efficient Economy[11] 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.

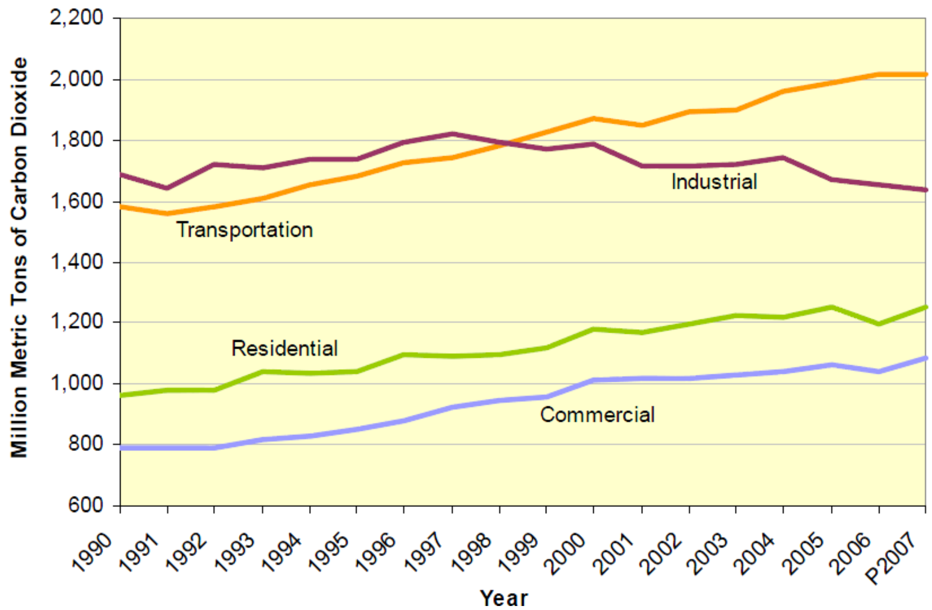
Greater energy efficiency will almost certainly be an important component in comprehensive national—and global—strategies for managing energy resources and climate change in the future. Energy efficiency is generally acknowledged to be the lowest cost and fastest-to-deploy resource to slow the growth 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

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

[11] 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.

in the short term although legislation encouraging greater energy efficiency in the U.S. manufacturing sector is possible.

Figure 3: U.S. Energy-Related CO_2 Emissions by End-Use Sector, 1990-2007



Source: ACEEE[12]

2.5 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 continual 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 Advance Manufacturing Office, formerly the Industrial Technologies Program. In

[12] 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.

California, 49 assessments were completed for small and medium facilities in 2009 through 2011 and 38 assessments for large facilities between 2006 and 2011.[13]

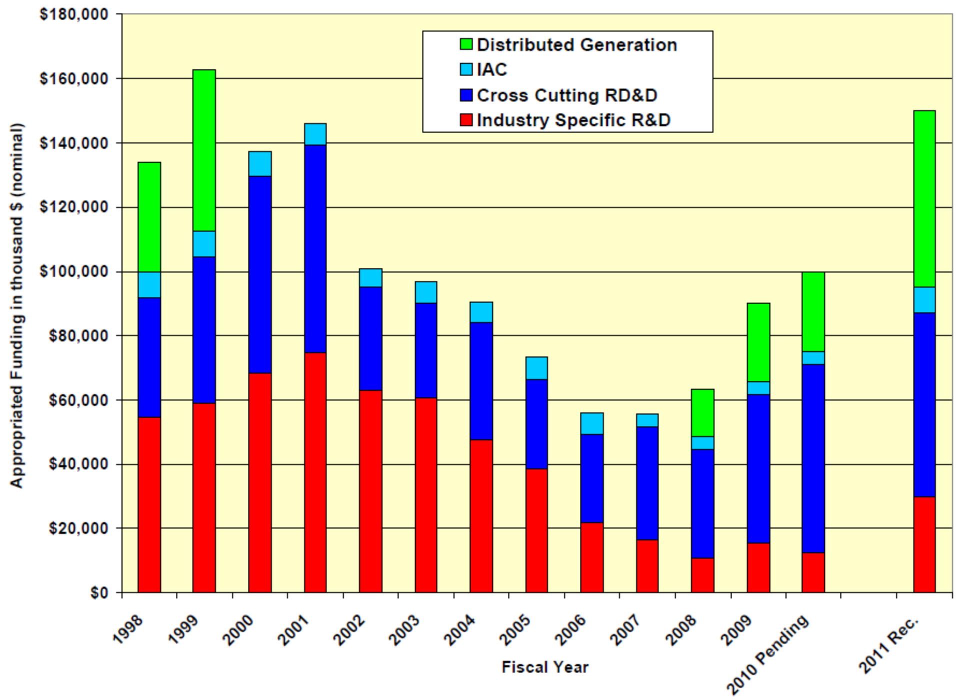
The U.S. DOE's AMO has been the primary federal entity supporting manufacturing R&D in partnership with industrial stakeholders. The AMO R&D program has been recognized as one of the most successful federal R&D efforts operating today. However, in recent years support for the program's R&D funding has 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."[14] 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: Save Energy Now and the Industrial Assessment Centers.

[13]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

[14] American Council for an Energy Efficient Economy. 2009. Barriers to energy efficiency investments and energy management in the U.S. industrial sector. http://www.aceee.org/files/pdf/fact-sheet/ACEEE-Barriers_to_industrial_EE_10-20-09.PDF

Figure 4: Industrial Technologies Program Funding, 1998-2010



Source: ACEEE[15]

Save Energy Now 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.

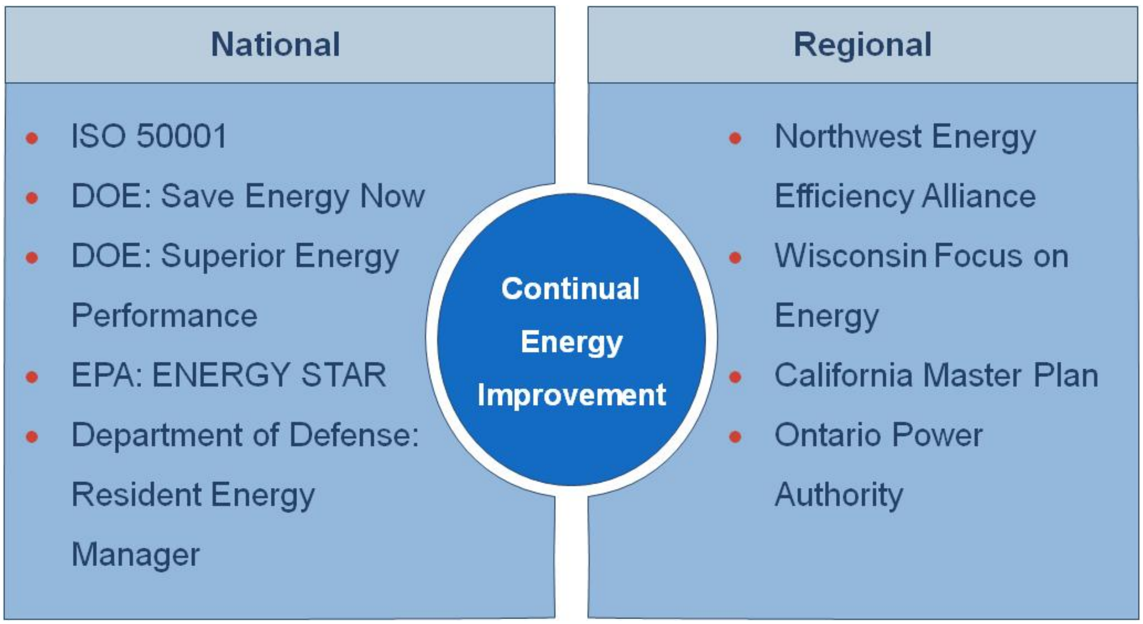
2.6 Rise of Continual Energy Improvement

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

[15] 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.

energy improvement (CEI) in industry. National programs in the United States have been developed by the U.S. DOE (Save Energy Now and Superior Energy Performance) and U.S. Environmental Protection Agency (EPA [ENERGY STAR]). Figure 5 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 5: 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.[16]

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.

[16] 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 U.S. DOE 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 large-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 50001; ANSI 50028 will provide the requirements for verification bodies for use in accreditation or other forms of recognition.[17]

Regional CEI programs have been developed under the Northwest Energy Efficiency Alliance,[18] working with the Bonneville Power Administration and the Energy Trust of Oregon. California has identified CEI as an important aspect of its strategic plan.[19] Similarly, Wisconsin's Focus on Energy employs an internally developed tool called Practical Energy Management©.[20] 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 significant commitments to energy efficiency programming as shown in Figure 6. 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.

---

[17] http://www.superiorenergyperformance.net/pdfs/SEP_Cert_Framework.PDF

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

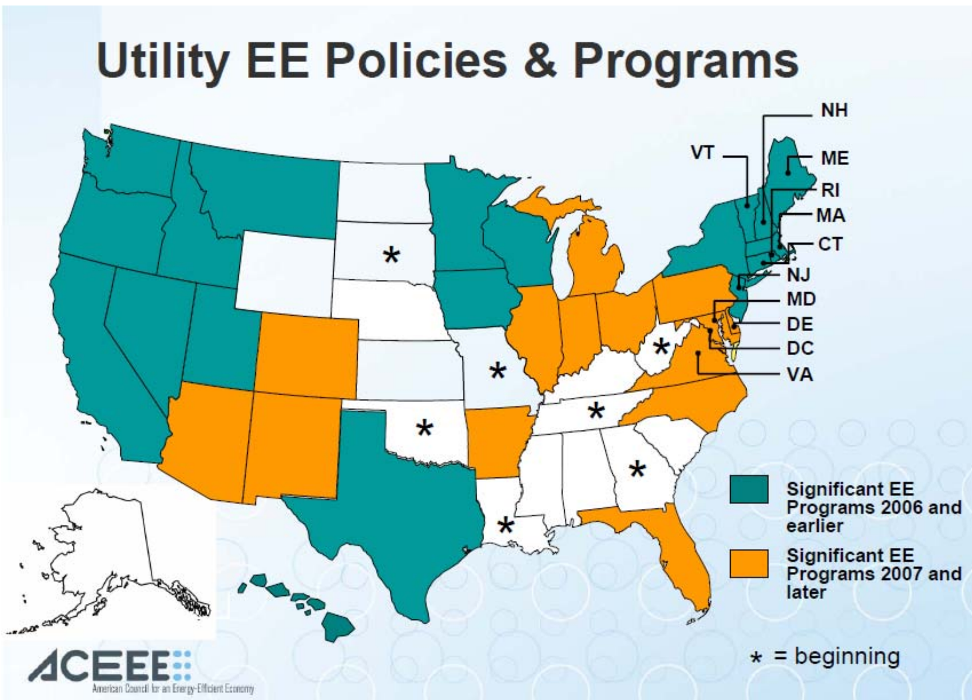
[19] California Public Utilities Commission. 2011. *CA Energy Efficiency Strategic Plan, January 2011 Update*. http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.PDF

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

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[21] policies[22] 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 6: Utility Energy Efficiency Policies and Programs, 2006 vs. 2007+



Source: ACEEE[23]

The electric Energy Efficiency Portfolio Standards 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

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

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

[23], Nadel, Steven. 2011. *Program Introduction*. (Presentation, ACEEE 2011 National Symposium on[23] American Council for an Energy Efficient Economy, Market Transformation, Washington DC, April 10–12, Conference 2011). http://www.aceee.org/files/pdf/conferences/mt/2011/Introduction%20-%20Steve%20Nadel.PDF

Carolina has until recently been relatively inactive in energy efficiency, but has enacted a renewable portfolio standard. Under this renewable portfolio standard, energy efficiency can meet up to 40 percent of the total requirements of the state's investor-owned utilities (IOUs) 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[24]

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[25]

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

[25] 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 minerals 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

Mineral products have chemical, crystalline, and structural properties that make them appealing for use in a wide range of applications, especially in buildings. Manufacturers in this industry transform relatively inexpensive and common raw mineral inputs like clay, lime, gypsum, and others into usable products like ceramics, tiles, wallboard, plaster, bricks, and stone slabs. The minerals industry is classified under non-metallic mineral product manufacturing (North American Industry Classification System [NAICS] 3-digit code 327), and is described by the following:

- Clay and porcelain product manufacturers (NAICS 4-digit code 3271)
- Lime and gypsum product manufacturers (NAICS 4-digit code 3274)
- Miscellaneous non-metallic product manufacturers, such as cut-stone products (NAICS 4-digit code 3279).

Glass manufacturing (NAICS 4-digit code 3272) and concrete manufacturing (NAICS 4-digit code 3273) are energy-intensive industries covered under separate reports. Although abrasive product manufacturing (NAICS 5-digit code 32791) includes whetstones and grinding products that are unrelated to the core building materials and chemicals focus of the other subsectors, there are some significant customers in California, so it is included in this report. Mineral wool manufacturing (NAICS 6-digit code 327993) is excluded here because it mostly consists of fiberglass manufacturers and is reported under the glass industry report.

Thirteen subsectors, listed in Table 4, comprise the mineral product manufacturing segment, as defined here. Companies in these subsectors manufacture clay, brick, ceramic, lime, gypsum, stone, slate, and other products, and examples from each subsector except non-clay refractory manufacturing can be found within California.

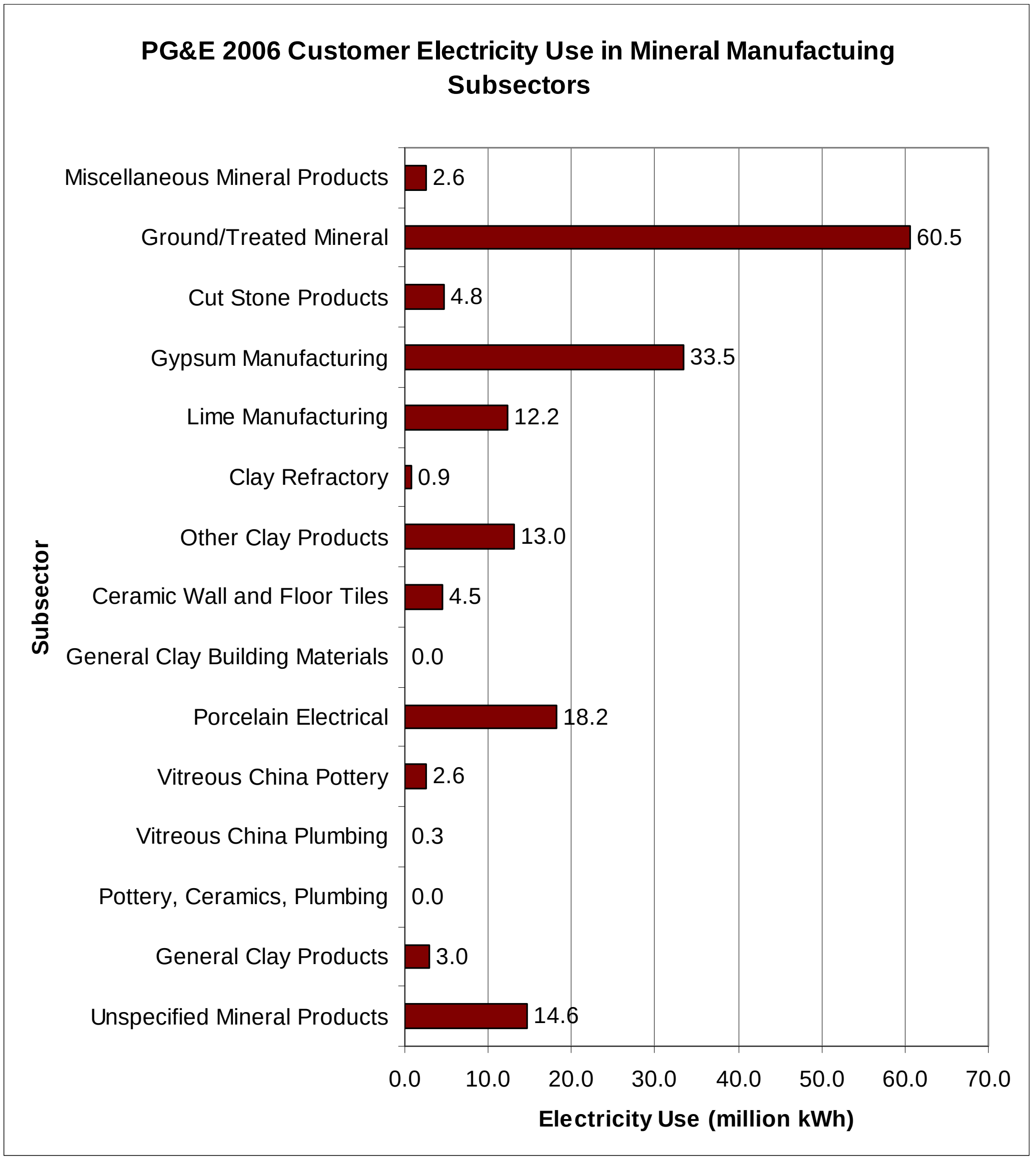
Table 4: Mineral Manufacturing in NAICS Code 327–Non-Metallic Mineral Manufacturing

327111	Vitreous China Plumbing Fixture and China and Earthenware Bathroom Accessories Manufacturing
327112	Vitreous China, Fine Earthenware, and Other Pottery Product Manufacturing
327113	Porcelain Electrical Supply Manufacturing
327121	Brick and Structural Clay Tile Manufacturing
327122	Ceramic Wall and Floor Tile Manufacturing
327123	Other Structural Clay Product Manufacturing
327124	Clay Refractory Manufacturing
327125	Non-clay Refractory Manufacturing
327410	Lime Manufacturing
327420	Gypsum Product Manufacturing
327991	Cut Stone and Stone Product Manufacturing
327992	Ground or Treated Mineral and Earth Manufacturing
327999	All Other Miscellaneous Nonmetallic Mineral Product Manufacturing

3.2 Energy Use

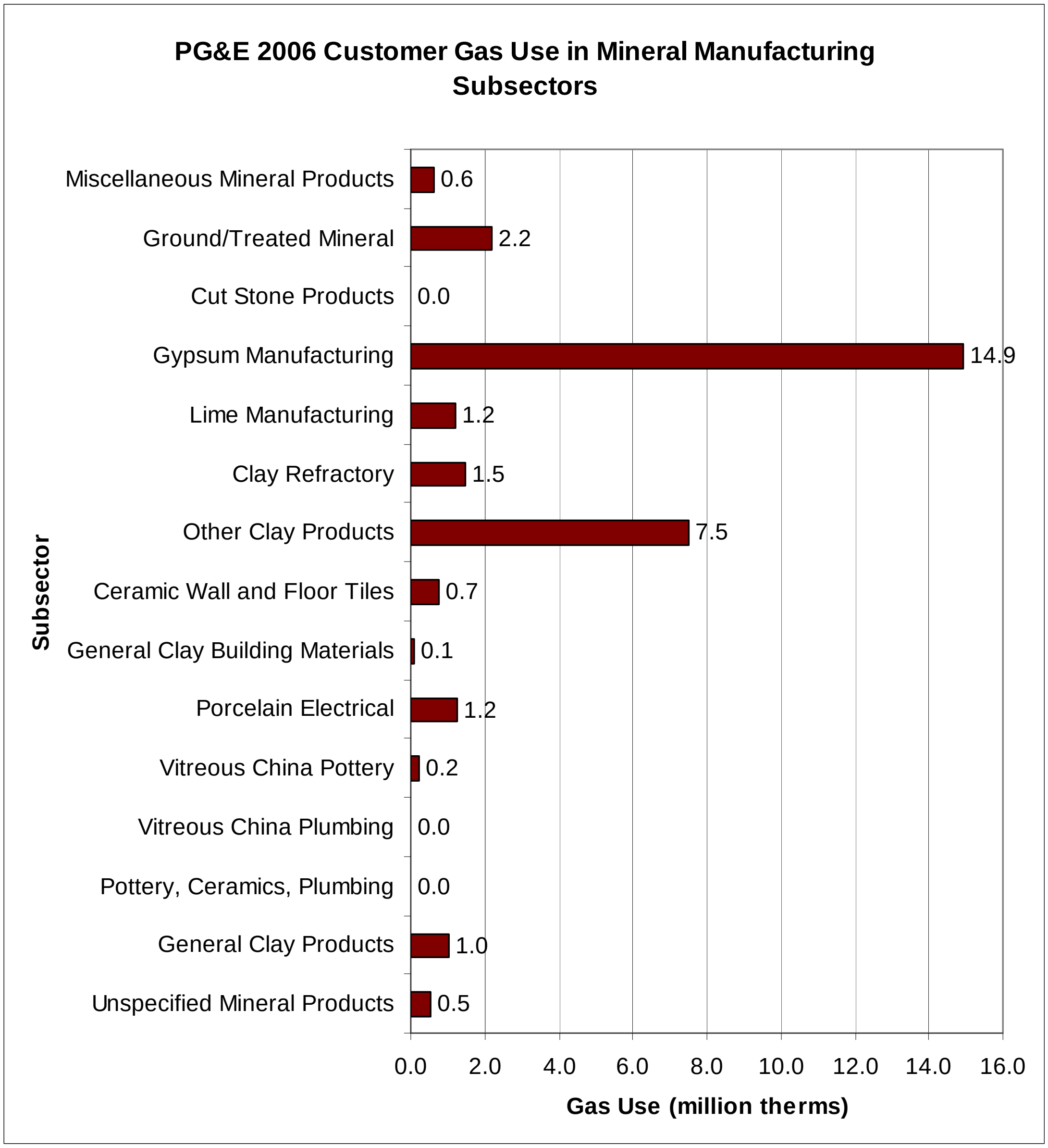
Figure 7 and Figure 8 show the sub-sector breakdown by 6-digit NAICS code of electricity and gas use in PG&E's territory. Figure 9 shows a similar breakdown in SCE's territory.

Figure 7: Mineral Manufacturing Subsector Electricity Purchases from PG&E



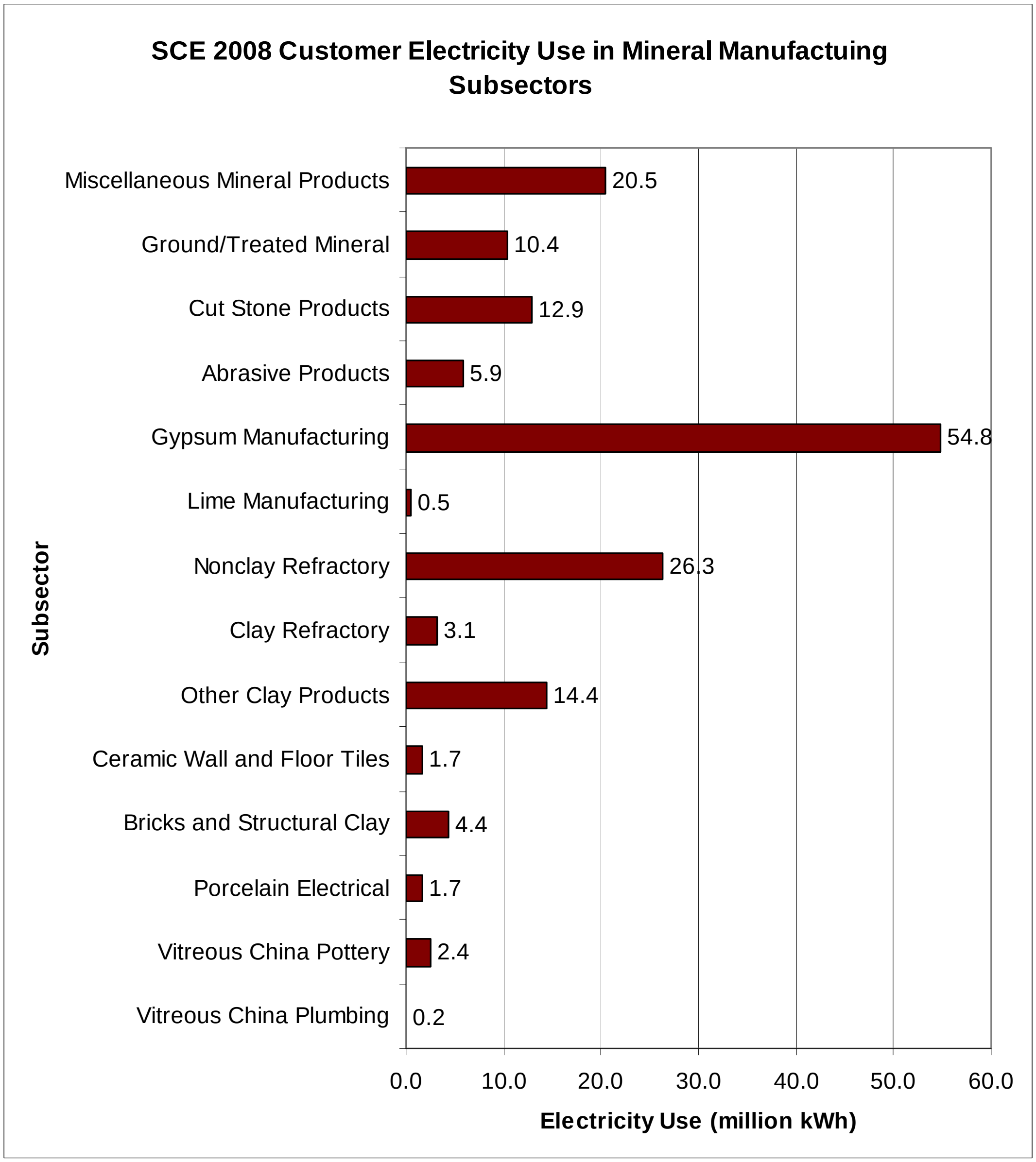
Source: PG&E data adapted by KEMA, Inc.

Figure 8: Mineral Manufacturing Gas Purchases from PG&E



Source: PG&E data adapted by KEMA, Inc.

Figure 9: Mineral Manufacturing Subsector Electricity Purchases from SCE in 2008



Source: SCE data adapted by KEMA, Inc.

Among mineral manufacturers, ground and treated mineral manufacturers dominate electricity usage. Gypsum manufacturers, porcelain electrical supply manufacturers, and other miscellaneous or unspecified manufacturers also make significant electricity purchases California. Among gas customers, the gypsum manufacturing and other clay product manufacturing subsectors, account for the most gas usage. Other subsectors have relatively small total gas usage.

3.3 Industry Landscape

Leading mineral product manufacturers fall into one of two categories: basic lime and gypsum companies or niche-dominating specialty-product manufacturers. Lime and gypsum manufacturers have traditionally been regionally based, due to the low-value to weight ratio of these products. However, the market for these products is relatively large compared to the market for other mineral manufacturing products, so global consolidation of ownership has been a trend in these subsectors over the last few decades. Consolidation of ownership has not necessarily led to consolidation of production, again due to the low-value to weight ratio of lime and gypsum. Therefore, most of the industry leaders are mid-sized global corporations based in the United States or Europe that own many geographically dispersed production and logistics facilities. Stone, clay, ceramic and other mineral product subsectors have smaller markets than lime and gypsum and have not been subject to the same trends. This has favored a focus on regional or sub-regional markets or specialization. Industry leaders not focused on lime or gypsum tend to be smaller, more specialized and focused on construction materials of various kinds. Celite Corporation is an exception, a specialized firm focused on filtration and industrial applications rather than construction.

California has representation from minerals-focused subsidiaries of many major global corporations. In terms of revenue, production, and energy use, the gypsum subsector is dominant. Among the leaders, there are also a few regionally based ceramic and building product manufacturers. Among the leaders, there are also a few regionally based ceramic and building product manufacturers. For both territories, reflective of the industry as a whole, ownership is indirect; local companies map through a maze of subsidiaries to global corporations, a significant portion of which are privately held.

3.3.1 Summaries of Major Manufacturers

U.S. industry leaders in California include the following. The source of the following information is the company websites of these organizations.

Carmeuse is a leading global producer of lime, high-calcium limestone and dolomitic stone for steel production, mortars, building materials and industry. With 4,600 employees and 90 production facilities in 13 countries, Belgium-based Carmeuse had revenue of €944 million in

2009. The company produced around 13 million tons of lime in 2009. Pittsburgh, Pennsylvania-based Carmeuse USA focuses mainly on markets in the Midwest and the South and has no presence in California, but has the largest share of the lime product market in the United States.

Ceradyne Corporation is a vertically integrated manufacturer of advanced technical ceramics for automotive, oil and gas, nuclear, medical, electronics, and defense industries. The company has a substantial product line ranging from body armor to dental crowns to neutron absorbing materials for nuclear reactors. With 2,000 employees worldwide and annual revenues around $400 milllion, Ceradyne is headquartered in Costa Mesa, California and has a major manufacturing plant there

Chemical Lime Company (CLC), fully owned by the Belgium-based **Lhoist** group for the last twelve years, is a 44-year old company with 17 production facilities and 14 distribution terminals. It now operates under the Lhoist North America group. The company is focused on the southwestern United States, employs around 2000 people, and has annual revenue around $250 million. It has one production facility in California (East Stockton, within PG&E territory) and a terminal in Stockton, as well as terminals in southern California.

Georgia Pacific Gypsum (GP Gypsum) is a wholly owned subsidiary of Georgia Pacific Corporation, itself a subsidiary of privately held **Koch Industries**, based in Wichita, Kansas. The flagship Dens Brand family of fiberglass mat gypsum panels is a leading product, but the product line also includes ToughRock gypsum board, moisture resistant gypsum panels, fire-resistant gypsum panels, joint systems, and roof-board. Based in Atlanta, GP Gypsum has 26 manufacturing plants in the United States, just over half of which produce gypsum wallboard. The subsidiary employs about 2,000 people and has 300 million tons of gypsum in its reserves. Overall, Koch Industries had nearly $100 billion in revenue in 2008. GP Gypsum has facilities in both northern and southern California and is one of the leading gypsum producers in PG&E territory.

USG Corporation is a global leader, with roughly half of its sales coming from the United States The firm is headquartered in Chicago and serves over one-third of the United States market. Although it has no facilities in PG&E territory, it is a major mineral product energy user in southern California. The company is vertically integrated operating 46 manufacturing plants, half of which are devoted to wallboard, 15 mines, and 8 paper mills. Under its North American subsidiaries, including U.S. Gypsum, the company produces the Sheetrock and Fibrerock brands of wallboard. During the recession, the company idled high-cost production facilities as wallboard sales declined 20 percent between 2006 and 2008 from $5.8 billion to $4.6 billion, with commensurate operating losses. Recovery has been slow for the company.

National Gypsum Company, employing 2,800 people, and Charlotte, North Carolina-based, serves about one-fifth of the domestic gypsum market. The company is vertically integrated. In addition to 21 gypsum wallboard plants (including one in Richmond, California), NGC owns 8 mines and quarries, maintains contracts for gypsum created from scrubbing coal-fired power plant emissions, owns 4 paper mills, and a transportation fleet. Major brands include Gold Bond, Durabase, and SoundBreak. The company closed a number of plants during the recession, as it saw its revenue drop from $1.7 billion in 2006 to $1.1 billion in 2008.

Armstrong World Products is a major worldwide producer of cabinets, ceilings, and flooring. With headquarters in Lancaster, Pennsylvania, the company employs over 10,000 people and earned $2.8 billion in revenue in 2008. Overall, the company has 36 plants in nine countries, with most in North America, and one in South Gate, California. Within mineral products, Armstrong makes residential and commercial floor products including ceramic and BioBased Tile under the brand names Armstrong, Bruce and Robbins, as well mineral fiber-based acoustic ceiling tiles for commercial construction.

Celite Corporation produces diamatomaceous earth products, chemically inert natural minerals, which have unusually light density and intricate structure, under the brand name Celite. Products are used mostly as filtration aids in the chemical, pharmaceutical, and food and beverage industries, but are also used as a functional additive in specialized paper, paint, rubber, plastic, cosmetic, polish, and food production. Celite Corporation is a subsidiary of Santa Barbara, California-based **World Minerals Inc.**, which supplies various diatomaceous earth and expanded perlite products throughout North America. World Minerals has 26 production facilities, including the Celite quarry near Lompoc. World Minerals is itself a subsidiary of French minerals conglomerate **Imerys**, which had €2.7 billion in sales in 2009. Although that was a 20 percent drop from the previous year, Imerys results improved in the second half of the year and were buoyed by consistent demand from emerging markets. Celite Corporation has benefited from its corporate parent during the recession, mitigating disputes organized labor had at multiple Celite facilities in the middle of the decade.

U.S. Tile is the leading seller of clay roof tile in the United States. It was acquired by Australia-based **Boral Limited** in 1988. Boral Limited is a vertically integrated resource-based manufacturing company serving building and construction markets throughout the Pacific Rim. With just under $5 billion in annual sales, Boral operates in 13 countries with 15,000 employees and over 700 operating sites. Financial performance was significantly hampered by the global recession.

In July 2010, the **MONIER Group** sold its interest in **MonierLifetile** in the United States to the Boral USA Group, a subsidiary of Boral Limited. The MONIER Group is among the world's leading producers of roofing products, with 9,600 employees and revenue of $1.2 billion in 2009. Before the transaction, MonierLifetile had been a 50/50 joint venture between MONIER and Boral. MonierLifetile is headquartered in Irvine, California and employs 360 people in twelve U.S. concrete roof-tile manufacturing plants, and 40 people in one Mexico manufacturing plant. Within PG&E territory, MonierLifetile operates one plant in Lathrop.

Grafil Inc. produces standard modulus carbon fibers with capacity to produce 3.2 million pounds per year. It is wholly owned by **Mitsubishi Rayon Co**., Ltd, which is a subsidiary of the Japanese Mitsubishi Group. Founded in 1984, it has a 60,000 square foot manufacturing facility outside of Sacramento.

Polycarbon, Incorporated is a wholly owned subsidiary of the SGL Group based in Valencia, California. The company manufactures flexible graphite foil in various forms for industrial applications and flexible carbon used in various automotive gaskets. Additionally, the company provides heat treatment and technical services for industrial and automotive customers.

Pacific Building Products is a horizontally integrated holding company with interests across the building product spectrum. Companies include Pacific Coast Supply, Basalite Concrete, Pacific Coast Building Products, Pabco Building products, Epic Plastics, Pacific Coast Transportation Services, Pacific Coast Jet Charter, and 5 other companies. Focused on the western United States, with heavy concentration in California, subsidiary companies have strong presence in PG&E territory. **Pabco Building Products** is based in Newark, California. Two of its subsidiaries are particularly notable. **Gladding McBean** operates a plant that manufactures vitrified clay sewer pipe, ornamental pottery, roofing tile, chimney tops and caps, and architectural terra cotta facades. **H.C. Muddox Brick** supplies a large distributor network with clay products that include standard face brick, thin brick, flue liners, pavers, pool coping and structural brick to be used on homes and commercial buildings. Pacific Coast Building Products is privately held.

3.4 Competitive Issues

Mineral manufacturing is a diverse industry and examples of unique business models can be found in almost every niche. However, a few general themes emerge from analyzing the industry as a whole. All mineral product manufacturers have a central imperative to meet customer needs for quality and timely delivery. With the exception of lime manufacturers, most mineral product manufacturers serve the construction industry, which demands materials which meet rigorous specifications to ensure safety and uniformity. Even though they serve a wide array of downstream industrial applications, lime manufacturers must also meet the imperatives of uniform quality and timeliness. Successful players in the mineral manufacturing market may control their own distribution networks, sign long-term contracts with major customers, take ownership of supply chains, or invest in manufacturing technology to ensure they supply their customers with consistency and quality.

Many mineral products, especially lime and gypsum but also cut stone, crushed stone and others, have low-value to weight ratios. They are also fairly common. In the past, this led to the growth of regionally focused companies which could leverage local supplies for processing and then distribute to local customers. Globalization and industry consolidation has occurred in ownership, but production remains geographically disperse. Competition for many of these heavy, low-value mineral manufacturing products revolves around price. Many, but not all, companies have adopted vertical integration, taking control of mining, manufacturing, and distribution in order to capture economies of scale across geographically segmented markets, and still reliably deliver products. This has led to conglomerates with a web of subsidiaries that stretches across the country or around the world. Production may be local, but ownership may be indirect and corporate management far away.

At the same time, there is a cross current of successful businesses in the industry that meet the business imperatives through other models: adding value through product differentiation, serving specialty markets, or maintaining a monopoly on a narrow product segment. While these manufacturers still must deliver high-quality products in time, they face less competition and price pressure than gypsum, lime, and crushed or cut stone manufacturers. They may employ a higher level of technology or more skilled labor in order to maintain a competitive advantage.

3.4.1 Operational Models

There are two prominent business models, vertically integrated and specialty producer, that cover most of the businesses in the mineral manufacturing industry, but examples of many other models abound. Most lime and gypsum producers are vertically integrated, owning and operating the mines, controlling the manufacturing process, and operating their own distribution networks. It is common for lime and gypsum companies to have a similar number of manufacturing facilities as distribution terminals. Gypsum producers primarily serve the construction market, so the vertically integrated model allows them tight control of their supply chain and the ability to provide nearly on-demand products to major homebuilders and construction firms. Lime manufacturers serve a broad range of industrial segments like steel, construction, and chemicals, and provide a fairly uniform product to all of them. While the market for their products is more diversified, controlling the supply chain gives lime manufacturers an advantage in meeting both rigorous quality demands and timely delivery. Chemical Lime Company, USG, and National Gypsum are examples of vertically integrated businesses.

Specialty product manufacturers also thrive in this segment. Celite Corporation is a world leader in diatomaceous earth products, an extremely useful, specialized mineral product. Other manufacturers create advanced ceramics for industrial uses or unique products for the construction market. Some of the businesses may be smaller, niche operations but if the specialty market is large enough, as it is for Celite, then these specialty businesses can capture substantial revenue.

Other business models includes Pacific Building Products' horizontally integrated business model—selling everything a construction industry might need from lumber and its own manufactured gypsum to hauling. It maintains a regional focus on the West Coast and uses long-term contracts with customers to its advantage. Other companies are small artisanal producers that compete on the basis of the superior quality and artistic design of their products, selling low volumes but clearing high margins. Finally, some companies produce advanced technical products for niche applications. Morgan Advanced Ceramics make specially designed and coated ceramics for aerospace, telecom, and other applications. Specialty producers tend to have an intense customer focus, strive to create a reputation for quality, and maintain extremely close relationships with their customers.

3.4.2 Cost Structure

There are a wide variety of cost structures within the mineral product-manufacturing segment. Table 5 shows key statistics on four different subsectors within mineral product manufacturing, which illustrates the full spectrum of variation.

Table 5: Key Statistics for Four Different Subsectors

		Gypsum	Lime	Clay Brick and Refractory Products	Miscellaneous Mineral Products[26]
Key Figures	Industry Revenue	$5.8B	$1.7B	$5.5B	$5.8B
	Employment[27]	10,500	4,100	26,000	23,000
Cost Structure[28]	Purchases	35%	14%	28%	33%
	Labor	13%	17%	28%	24%
	Utilities	13%	23%	10%	5%
	Other[29]	11%	3%	9%	8%
	Profit	29%	44%	26%	31%
Comparative Description		*Capital Intensive*	*Energy Intensive*	*Labor Intensive*	*Mixed*

Source: Various (see above)

In general, materials purchases, labor, and utilities combine for the majority of spending in the industry. Mineral manufacturing is generally capital intensive, but especially so for commodity products like lime and gypsum. There is a high level of sunken capital in both of these industries. Although it is relatively labor intensive for mineral products industry, the labor intensity of clay product manufacturing is actually around the United States average for all industries, again highlighting the skew towards capital intensity in the mineral product segment as a whole. Specific examples of especially labor-intensive production can be found, most

[26] Excludes mineral wool manufacturing. Revenue and employment have been scaled down based on industry breakdown fractions from IBISWorld. Cost structure percentages from IBIS World reports reflects contribution from mineral wool manufacturing, but it is assumed to be similar to the other subsectors

[27] U.S. Census Bureau. 2008. *2006 Annual Survey of Manufacturers*. November 18, 2008.

[28] Cost structure from IBISWorld Reports. Numbers may not add to 100% due to rounding.

[29] Depreciation and other miscellaneous costs

notably for high-quality or hand-crafted construction materials. In these cases, labor costs dominate, but the market size is fairly limited.

Materials and energy make up a third to half of costs on average. Given the industrial and construction markets, the materials portion of costs is not surprising and much of the raw material ends up in the final product. Up to 25 percent of total costs for some subsectors are related to utilities, although in the relatively energy intensive subsectors much of utility expenses are related to purchased fuels, primarily natural gas for all sectors except lime manufacturing. Lime manufacturers rely heavily on coal (see Figure 4.1 in section 4). Electricity tends to be a small portion (generally a few percent) of costs for most mineral manufactures. Energy costs are highest among lime manufacturers because lime manufacturing involves kiln drying. However, profit margins are also highest for lime manufacturers, despite the large portion of costs going to energy. This suggests that the profits for lime manufacturers in particular are vulnerable to changes in energy prices, especially since lime spans a broad market. Other market players have profit margins less susceptible to energy price movements, but more beholden to demand from narrower markets like the construction industry.

3.4.3 Technology Development

Enhancing production flexibility and responding quickly to varying customer demand both drive technology development in the mineral manufacturing industry, often through automation and better control. At the same time, automation allows producers to maintain tighter product specifications and provide higher levels of customization to major customers. With price-driven products like lime, gypsum, and crushed stone, improved technology lowers unit production costs and does provide a competitive advantage. Higher capacity machinery can boost overall productivity and may warrant investment, but there is an upper limit on useful capacity imposed by high transport costs and low-value to weight ratio of most mineral products. Markets are geographically narrow, so machines that increase production flexibility are more valuable than machines that increase overall output.

The most sophisticated companies have highly automated production lines, using computer-aided design (CAD) and computer-aided manufacturing (CAM) equipment. Companies rely on a combination of belts, crushing devices, chemical mixers, rollers, and in some cases kilns and forming machines to produce their goods. For instance, a single gypsum wallboard may travel over hundreds or even thousands of feet of conveyers throughout the manufacturing process. The more sophisticated equipment users need more engineering and process design and better trained technicians to run the equipment. Cut stone manufacturing in particular has been transformed by technology; using computer control is almost essential to be competitive. The advantage of modern technology is the ability to maintain tighter specifications and produce output faster. Almost as critical is that new technology provides production flexibility, particularly among producers who must respond to cycles in residential and commercial construction. The disadvantage of new technology is the capital cost, so larger more established companies with more ready access to capital are more likely to invest in new technology. Larger, more established companies almost always have a relatively large amount of sunken capital.

3.4.4 Supply Chain Management

Customer demands make effectively managing the supply chain, especially distribution, a core business requirement for mineral product manufacturers. This has led to vertical integration among many of the largest firms, controlling product supply. The largest lime and gypsum manufacturers own mines and mining interests with enough minerals to meet decades worth of demand. Other large players in PG&E territory like Celite Corporation also own their own mines. Upstream supply chain management for the major corporations consists simply of moving raw minerals to the yard or factory for production via a combination of belts, trucks, and trains. Factories tend to be located close to the mines to minimize transport costs. Distribution is regional, through company-owned distribution terminals and companies invest significantly in order management systems. In many cases, companies transport large volumes of factory output to central distribution terminals via their own operational fleet. From the regional distribution terminals, companies distribute locally to their customers, using the most efficient means possible. Many manufacturers will supply their large commercial construction and homebuilding customers (or steelmakers in the case of lime) directly— thereby operating the entire supply chain. This allows companies full visibility into their orders, enabling them to tune production accordingly. It also allows companies to ensure quality from start to finish. In addition to lime, gypsum, and stone manufacturers, some high-volume clay producers, like brick makers, follow this model.

Smaller companies making specialty products for niche markets leverage typical freight and trucking distribution for upstream and downstream supplies. Serving technical and artisanal niches, these companies produce products which have significant value. While relying on regional markets for common minerals, they source specialized inputs for production from wherever they need and distribute to customers across the country. In some cases, the value of the product is so high and technical specifications so rigorous that the distribution challenge is getting it to customers safely. For instance, manufacturers of aerospace ceramics used in spaceflight and aeronautical instrumentation must take great care to ensure no flaws develop in their product prior to customers accepting delivery.

3.4.5 Product Development and Roll-out

There is a surprising amount of innovation and new product development in the mineral product-manufacturing sector. Among manufacturers who have proven they can deliver high-quality products to major customers on time, product differentiation can sometimes give a competitive edge. For instance, brick markets have fairly uniform prices and subtle changes in coloring, design, or *feel* can capture changing consumer preferences. Clay roof tile manufacturers have lost market share to lighter, cheaper substitutes like polyvinyl chloride (PVC) tiles, but some manufacturers have used innovation to keep their position from eroding further. Carbon-core roof tile is a recent innovation which promises added strength and longevity by mixing composite material with traditional clay materials. U.S. Tile has focused on products that enhance building energy efficiency. So-called cool-roof tiles do not absorb heat. A different line of unique clay tiles has integrated photovoltaic cells. Manufacturers with innovative products usually roll them out through relationship marketing, introducing them to established customers who already trust the ability of the manufacturer to deliver products on time and on specification. Particularly inventive products often get consumer media coverage from home and garden reporters (e.g., HGTV, home shows, etc.), although few manufacturers actively seek this attention.

Lime manufacturers responded quickly and successfully to new demand for their product in air pollution scrubbing applications arising out the 1990 revision to the Clean Air Act. Because it is an inexpensive, effective part of the scrubbing process, lime manufacturers had to do relatively little product development or marketing to capture this revenue. Gypsum manufacturers, on the other hand, took longer to recognize that post-scrubbing by-products contain gypsum; creating a new supply source for them. The product—gypsum wallboard—stays the same, but rolling out synthetic gypsum as a raw material and maintaining the specification represents real innovation. The major gypsum manufacturers have recognized the advantages. Every new gypsum wall-board factory built in the last five years has been co-located with an industrial facility using air pollution scrubbing equipment.

Some subsectors within mineral product manufacturing are quite mature and see minimal new product development. Clay refractory product manufacturers serve mature, industrial markets with replacement products that are essential to customers being able to use their equipment. Delivering on tight schedules which minimize the downtime of customer production equipment is tantamount to new product needs. Porcelain fixture manufacturers have relatively few ways to improve performance of their products; most applications have been around hundreds of years. For this type of product, regularly updating products to consistently follow design trends is more effective than technical improvement.

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 the combined inputs. 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 mineral products sector there are two ways producers create value. First, among lime, gypsum, and ground stone manufacturers, value comes from the business model and distribution system. Many of the large-scale players in this industry are vertically integrated, owning mineral quarries through to end product distribution networks. Large-scale, vertically integrated manufacturers can access raw mineral quarries within a reasonable proximity to customers. One value-add between quarrying and sale of final mineral products is related to the fact that the existing vertically integrated company may control a substantial amount of activities needed to mine raw materials and turn them into final mineral products. Mineral manufacturers add further value through distribution, when they deliver products on specification and on time, in response to customer activities.

Second, smaller more specialized mineral product manufacturers create significant value by adding superior technical expertise, highly trained labor, improved design, and/or specialized equipment to create products and services for niche markets. There is a much higher value-add for niche players making products such as advanced ceramic composites or designer porcelain wash basins but much lower volumes.

3.4.7 Pricing

There is substantial price competition for most mineral product manufacturers. Because many mineral products are ubiquitous and most raw inputs are commonly found, price differentiation can be intense among established companies who can reliably manufacture products to specification and deliver in the quantities customers need on the schedules customers need. Competition comes from other manufacturers of the same subsector and in some cases, substitutes from other industries. With some materials like clay roof tiles, globalization has put significant downward pressure on prices. At the same time, some industries like lime manufacturing still maintain highly regionalized markets. In the regional markets, there are usually only a few options for customers, thereby allowing the manufacturers to maintain some power to keep prices higher. Products in general have relatively low value, especially in relation to their weight, but there is also little cross over between segments—one type of product (e.g., crushed stone) is usually not substituted for another (e.g., cut stone). The lack of cross over and low-value to weight ratios together keep prices from falling where they otherwise might in a global market. Energy-intensive manufacturers, like lime producers, also maintain the power to move prices in response to energy prices.

It is also not uncommon to find long-term contracts between major residential or commercial builders and large mineral product manufacturers. These contracts serve to dampen volatility and favor slower movements in prices. Because the construction industry is highly cyclical, long-term contracts also give mineral product manufacturers some price certainty. During the recent recession, manufacturers were able to slash production considerably and maintain price levels despite greatly reduced demand.

There is a small portion of firms who command premium prices. Some building product manufacturers market to consumers and support high prices through superior craftsmanship, superior design, or unique function. Cutting-edge technology firms support high prices through innovation, research, and technical performance in scientific, aerospace, and other applications. However, these are usually niche markets.

3.5 Economic Factors

3.5.1 Business Cycles

Because the construction industry drives the majority of demand for mineral products, most manufacturers must respond to business cycles in real estate development and investment. Most subsectors within mineral product manufacturing saw a cyclical peak in revenue around 2005 and 2006. Since then, there have been declines in revenue in the range of 20–30 percent, according to a cross section of IBISWorld reports. Major players with deeper resources have weathered the recession, but weaker and smaller design-driven or specialty firms have simply gone out of business. Even lime manufacturers, which serve a broadly diversified set of customers, are subject to business cycles because around 30 percent of lime sales go to the steel industry. Steel output, and therefore lime demand, is highly dependent on industrial business and investment cycles. The lime industry was in considerable decline between the mid 1990s and mid 2000s in response more to the overall contraction of the steel industry in the United States, although the impact on lime manufacturers was partially offset by growth in the emissions control market. Makers of specialty and technical products, like aerospace and military-oriented ceramic manufacturers, are more responsive to cycles in government defense spending. Anecdotal evidence would suggest that some defense-oriented manufacturers have seen steady revenue growth due to ongoing U.S. military engagements around the world, but specialty defense firms often purposely make hard numbers difficult to obtain.

3.5.2 Availability of Capital and Credit

Many of the largest mineral products manufacturers are subsidiaries of large multi-national corporations, many of which are privately held. As such, parent companies can fund new projects and facility improvements from operating cash. They also have access to the corporate debt market and issue bonds, but they sport a range of credit ratings. Many credit ratings are changing, although there is no industry-wide trend. For instance, Standard and Poor's raised the credit rating of Georgia Pacific from BB- to BB+ in late 2009, but lowered the rating of U.S. Gypsum to B- in early 2010. Diversified parent companies, like Koch Industries, may be able to obtain much more attractive debt terms than their mineral product focused subsidiaries. At the same time, much of the capital for mineral product manufacturing is sunk—meaning there are high upfront capital requirements, but little new capital is required later because the pace of technological change is slow. A broad trend towards consolidation of ownership (but not operations, which remain heavily segmented into relatively narrow geographic regions) ended in 2008 when credit markets froze. Acquisitions leveraging high levels of debt ceased and have not resumed.

Smaller players typically need new capital up front to establish operations and therefore can be saddled with debt from launch. During the recession, few new businesses began operations because little credit was available to pay for the sunken costs associated with startup. Venture capital is generally not available because the conceivable markets are so specialized that they will unlikely ever achieve the rapid growth sought by venture capitalists. Many small businesses take collateralized loans to begin operations. Costs for such credit have gone up considerably, representing a higher barrier to entry for new entrants into the field. Artisan and designer mineral product manufacturers may be able to start and grow operations with only small amounts of capital or entirely on credit, but they face limited growth prospects.

3.6 Regulatory Issues

The mineral products industry is subject to a long list of environmental regulations on federal, state, and local levels. Additionally, there are a number of minerals product standards that ensure building safety. The following sections describe the regulatory issues facing the mineral products industry.

3.6.1 Environmental

The minerals industry must comply with the following environmental laws:

- The Clean Air Act (CAA) regulates air emissions from stationary and mobile sources. Key pollutants are defined as particle pollution (often referred to as particulate matter), ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. Regulated sources are stationary sources or a 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. Lime manufacturers in particular were added in 2004, meaning that they are subject to regulations requiring the installation of hazardous pollutant emission control technology when permitting new plants or existing plant retrofits. Porcelain and ceramic manufacturers also must pay close attention to CAA rules, as many glazes contain lead and reactive fluorine.

  Lime and gypsum have each profited in separate ways from air scrubbing technologies. Lime is used as a scrubbing agent for sulfur emissions, which means the CAA has opened up a new market for lime manufacturers. Gypsum manufacturers have been able to post-process scrubbing by-products into synthetic gypsum, which is a low-cost substitute raw material.

- 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, 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 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 the 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.

- The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 is also known as the Superfund. Mineral products manufacturers incur the costs for rehabilitating plant sites contaminated by hazardous substances.

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 mineral products industry are 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 legislation signed into law in the United States to establish mandatory limits on GHG emissions. 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 GHGs.[30] Starting in 2009, California facilities that emit more than 25,000 metric tons of CO_2 equivalents must report their emissions to the ARB. Starting in 2010, all reporting entities must have their emissions reports verified by an accredited third party auditor. Most mineral products manufacturers fall well below the threshold that requires compliance, although large lime manufacturers (e.g., Chemical Lime Company) are subject to mandatory reporting.

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.

[30]These gasses include methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). 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).

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.

Major lime manufacturers and a few other large mineral manufacturing operations in California are 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 greenhouse gas emissions. 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. As California implements AB 32, affected minerals manufacturers can expect to be treated as capped sources. The implementation of the cap-and-trade 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 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.

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. Recent analysis by the California Legislative Analyst suggests that this effect will not be significant for the overall economy. Sectors most affected are likely those with high-energy-intensity and significant trade-related activities where increased costs may not be able to be reflected in higher prices.[31]

[31] Taylor, Mac. 2011. *Letter to Honorable Dan Hogue*., California Legislative Analyst's Office. May 13, 2011. http://www.lao.ca.gov/reports/2010/rsrc/ab32_logue/ab32_logue_051310.PDF

EPA Mandatory Reporting

The U.S. EPA issued a rule for mandatory GHG reporting from large emissions sources in the United States. In general, the rule calls for facilities that emit 25,000 metric tons or more of GHG emissions per year to submit annual reports to EPA. From 85–90 percent of total national U.S. GHG emissions, from approximately 13,000 facilities, are covered by the proposed rule. As with AB 32, only large lime manufacturing plants in the minerals sector are likely to have sizable 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,[32] 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. 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.

3.6.3 Mineral Product Standards

The ASTM has a number of standards for mineral products, primarily to ensure safe construction and fire resistance. There are literally hundreds of standards related to lime, gypsum, ceramics, and clay products. These standards govern structural specifications, chemical tolerances, durability, water resistance, acoustical properties, and more, depending on the product. Gypsum, lime, clay, and ceramics all have families of ASTM standards. Some of the important ASTM standards include:

- C207-91(1997), Standard specification for hydrated lime for masonry purposes
- C911-99e1, Standard specification for quicklime, hydrated lime, and limestone for chemical uses

---

[32] 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

- E1266-88(1999), Standard practice for processing mixtures of lime, fly ash, and heavy metal wastes in structural fills and other construction applications
- C977-02, Standard specification for quicklime and hydrated lime for soil stabilization
- C1396, Standard specification for gypsum wallboard
- Additional testing standards

In addition to ASTM standards, most mineral manufacturers conform to standards set by industry-backed quality and testing agencies. Many mineral manufacturers are accredited for manufacturing quality under ISO 9002.

3.7 Industry Network

- The **National Lime Association** ([NLA], www.lime.org) is the major U.S. lime industry trade group. NLA is comprised primarily of producer member companies and member companies account for nearly 90 percent of lime produced in the United States and Canada. From its headquarters in Arlington, Virginia the group engages heavily in advocacy, but also maintains a technical forum, sponsors conferences, and funds market research for the lime industry. Many promotional reports, brochures, and lime product descriptions in the public domain are products of the National Lime Association.

- Founded in 1930, the **Gypsum Association** (www.gypsum.com) is an industry advocacy and trade association for the gypsum industry. Its 10 major member companies account for nearly all the gypsum wallboard production in the United States; GP Gypsum, U.S. Gypsum, PABCO, National Gypsum are all among the member companies. The Gypsum Association maintains a technical and educational clearinghouse, conducts deep technical and market research, coordinates building standards, and serves as the primary industry voice with government.

- The **Brick Industry Association** ([BIA], www.gobrick.com) is the national trade association representing distributors and manufacturers of clay brick and suppliers of related products and services. The association is a nationally recognized leader on clay brick construction and represents the industry in all model building code forums and national standards committees. BIA serves as an industry liaison for major market, regulatory, and technical developments, coordinates technical and engineering standards, maintains engineering literature, promotes the industry through communication, performs advocacy, and offers industry awards.

- With 9,500 members, the **American Ceramics Society** ([ACerS], www.ceramics.org) is a technical and professional society for individuals involved in ceramic materials or technologies. Over 100 years old, ACerS seeks to foster a professional community, emphasizing relationships, knowledge transfer, and education. Conferences, publications, and technical forums are a particular focus. Although most of its activities are focused on the United States, around 30 percent of its membership is international.

- The **National Sand, Stone, and Gravel Association** ([NSSGA], www.nssga.org) is the primary national advocacy organization representing the aggregates industry. With particular focus on influencing environmental legislation, NSSGA puts considerable resources into lobbying and grassroots campaigns. The organization also advises members on community relations. Sustainability has been a particular emphasis in recent years. In addition to regular communication activities, NSSGA hosts an annual national industry convention with over 5,000 attendees. Among its educational initiatives, it maintains a Youth Leadership program and organizes ongoing training and technical seminars for its members. Finally, NSSGA has partnered with the Smithsonian to oversee a $1.7 million endowment to support education, temporary exhibits, and a permanent exhibit called “The Rocks Gallery.”

- A small non-profit trade association called the **Building Stone Institute** ([BSI], www.buildingstoneinstitute.org) is a 90-year old organization for dealers, importers, exporters, carvers, restorers, designers, and installers of building stones. The organization provides programs and education to enhance quality and use of building stones.

- The **Marble Institute of America** ([MIA], www.marble–institute.com) promotes the use of not just marble, but also all other natural dimensional stones like granite, soapstone, sandstone, travertine, and so forth. MIA is the largest trade association for natural dimensional stone, providing advocacy, networking, marketing/publicity, and information/education. It is also a central resource for professionals about stone craftsmanship.

- For over 65 years, the **Tile Council of North America** ([TCNA], www.tileusa.com) has the sole purpose of expanding the market for ceramic tile in the United States, Canada, and Mexico. It is a trade association representing manufacturers of ceramic tile, tile installation materials, tile equipment, raw materials, and other tile-related products. TCNA regularly conducts independent research and product testing, works with regulatory and trade agencies, offers professional training, and publishes installation guidelines, tile standards, economic reports, and promotional literature.

Smaller industry associations serving an ecosystem of specialty producers also exist, but most of them lack significant resources or advocacy clout.

3.7.1 Supplier and Trade Allies

Mineral product manufacturers have a number of trade allies, companies that work with or support the industry. Trade allies can be broken down generally into firms that focus on design and engineering, firms offering efficiency and optimization, consultants, and environmental service providers. Many of the firms focusing on efficiency and optimization specialize in gypsum, lime, or other specific parts of the industry only, but the environmental firms are more general, typically working with all types of industry, not just those in the mineral product industry. Size amongst various trade allies is inversely proportional the specialization—smaller companies tend to focus intensely on subsectors within minerals manufacturing while the larger companies tend to include all minerals manufacturers as only a part of a larger portfolio of clients. The following list provides some examples of trade allies of mineral product manufacturers.

- Design and engineering firms offer services related to site selection for plants, architecture, plant engineering, equipment design, construction, technical services for kilns and other equipment, process expertise, problem solving, training, innovation, production supplies and management.
    - Gypsum Technologies [gypsum]
    - Swindell Dressler [clay and technical ceramics]
    - MAC Industries [lime and other mineral products]
- Specialized equipment manufacturers, providing full services specific to individual elements of the mineral manufacturing process, i.e., crushing and grinding, dust collection, or kilns. These engineering and manufacturing firms provide design, innovation, and technical services related to their products. Many times they specifically offer efficiency and optimization services.
    - IMS Engineering [crushing and grinding]
    - Dantherm Filtration USA [dust collection]
    - FLSmidth [lime kilns]
    - Harrop Industries [ceramic kilns]
    - Ancaster GWE [conveyors and mixers]

    - ZVEI [process automation]
- Consultants often employ former mineral process industry employees and provide solutions encompassing analytic services, process assessment, design, management, testing and certification, financials, and innovation management. Often these firms are in competition with industry associations.
    - Innogyps [gypsum and innovation]
    - Q.C. Environmental [clay products]
    - NSL Analytics [product testing and certification]
    - SAIC [energy efficiency]
- Environmental and air-quality firms provide equipment, emission control systems, and expertise to enable environmental compliance
    - Ducon
    - CECO Environmental

4. Target Technologies / Processes and Energy Efficiency

Mineral product manufacturers typically have processes which are neither technologically complex nor particularly energy intensive, although there some notable exceptions. The industry as a whole does not consume a disproportionate share of energy and many small and specialized mineral product manufacturers are not significant energy users. The highest revenue segments—lime and gypsum—along with clay and ceramic manufacturers all utilize kilns of varying types for parts of the production process. Kilns are the most energy-intensive elements of the entire industry and represent a major target for energy efficiency. Efficiency improvement potential among other parts of the manufacturing process is typically incremental, although a few firms are trying to develop disruptive technologies which greatly enhance energy efficiency.

4.1 Energy Use

According to KEMA's analysis, the mineral product manufacturing industry in total used between 250 and 300 trillion Btu in 2006, or slightly above 1 percent of the United States total. Lime and gypsum manufacturing are each characterized in the Manufacturing Energy Consumption Survey (MECS) but the other mineral product manufacturing segments are not. Sectors are not included in the MECS because their energy use is too low or there is insufficient survey data reported by that sector. To project energy use for sectors not characterized by the MECS, KEMA estimated energy use for a sample of subsectors with IBISWorld total revenue calculations and energy spending breakdowns, U.S. Energy Information Administration average retail prices paid by industrial users, and U.S. EPA conversion factors for various types of energy. Our estimates of nationwide energy use by subsectors not in the MECS have much higher uncertainty than estimates for lime and gypsum manufacturing, but generally much lower total magnitudes of energy use.

Table 6 gives a breakdown of total energy consumption for a few sample subsectors, demonstrating the dominance of lime and gypsum manufacturing within the energy use profile. Our data was not specific enough to quantitatively describe the other subsectors, but most are smaller and they are all much less energy intensive than those listed in Table 6. Total energy use can be is reasonably small compared to the lime, gypsum, and clay and brick product manufacturing

Table 6: Examples of Subsector Energy Use for the United States

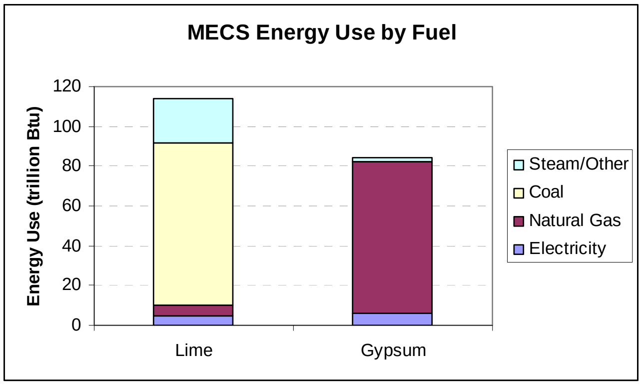
Subsector	Energy Use (Trillion Btu)
Lime Manufacturing	116
Gypsum Manufacturing	86
Clay Brick Manufacturing	29

Sources: Lime and gypsum from MECS data. Clay brick manufacturing derived by KEMA.

4.2 Energy Consumption by End Use and Energy Efficiency Potential

Data from the 2006 MECS gives a breakdown of national energy use by fuel type for the lime and gypsum industries. Although the gypsum industry generates three times the revenue of the lime industry, it uses only two-thirds the energy. Both industries use similar amounts of electricity, but most of the lime manufacturing energy use is in the form of coal and gypsum manufacturing energy use in natural gas. Some lime manufacturers also have combined heat and power operations, although most simply have coal-fired kilns. Energy use for the other mineral manufacturing segments is relatively small and is composed almost entirely of electricity and natural gas. Lime manufacturing is an exception to the more common pattern for the industry.

Figure 10: National Energy Use by Fuel in the Lime and Gypsum Industries



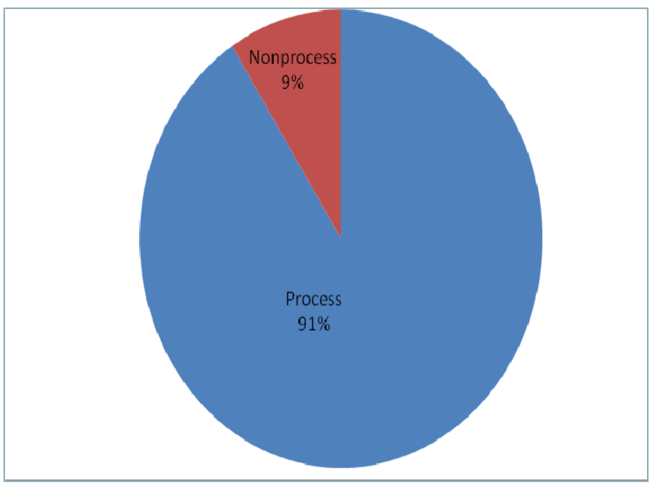
Source: Manufacturing Energy Consumption Survey tables, adapted by KEMA[33]

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

Figure 11 and Figure 12 display electricity consumption in the gypsum product manufacturing industry (NAICS 327420) and are based on national industry data from the 2006 MECS. The gypsum products industry was chosen for this analysis because of both its representativeness and significance (second largest electric and largest natural gas user in the mineral products subsector in PG&E territory) as well as the data restrictions of MECS. While KEMA acknowledges that the way in which gypsum manufacturers use energy could be different from the way other mineral product manufacturers use energy, unfortunately, MECS data exists for only some of the 6-digit NAICS codes that we examined, and the gypsum products industry was the most relevant 6-digit code available in MECS related to the mineral-products industry.

Figure 11 reinforces our findings that the majority of energy consumption (91 percent) by the gypsum product manufacturing industry is directly related to the mineral product process, specifically for kilns. Non-process energy use, like facility lighting and HVAC, accounts for a small fraction (9 percent) of the industry's electric consumption.

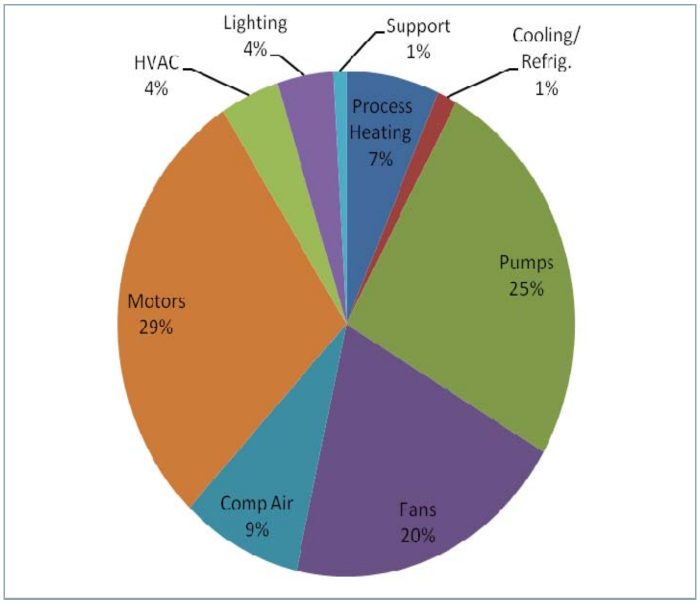
Figure 11: Mineral Products: Energy Consumption by End Use and Energy Efficiency Potential



Source: 2006 Manufacturing Energy Consumption Survey[34]

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

Figure 12: Gypsum Products Industry: Electric Consumption by End Use



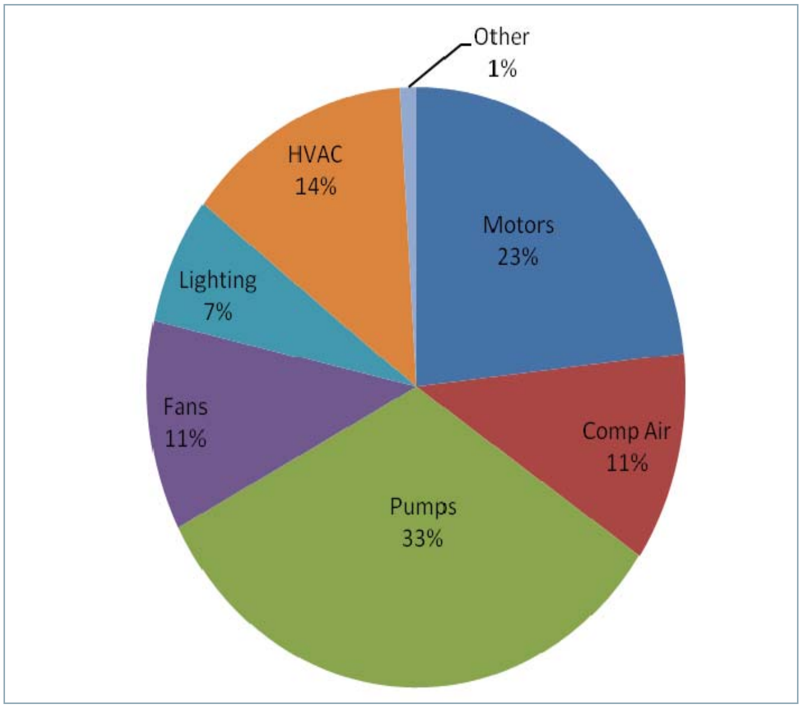
Source: 2006 Manufacturing Energy Consumption Survey

Figure 12 expands on the high-level consumption information presented in Figure 11 and shows electric consumption by end use for the gypsum products industry. Over 80 percent of total electric consumption in the gypsum products industry can be attributed to machine drives as defined by MECS. Using information from prior research, [35,36] we were able to break down machine drive consumption into motors (29 percent), pumps (25 percent), fans (20 percent), and compressed air (9 percent). Facility lighting (4 percent) and HVAC (4 percent) dominate non-process electric consumption in the gypsum products industry.

[35]KEMA and Lawrence Berkeley National Laboratory, 2005. California Statewide Industrial Sector Energy Efficiency Potential Study. Prepared for Pacific Gas and Electric Company.

[36] XENERGY. 1998. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Prepared for Oak Ridge National Laboratory and DOE's Office of Industrial Technologies.

Figure 13: Nonmetallic Minerals Products (NAICS 327): Electric Energy Efficiency Potential



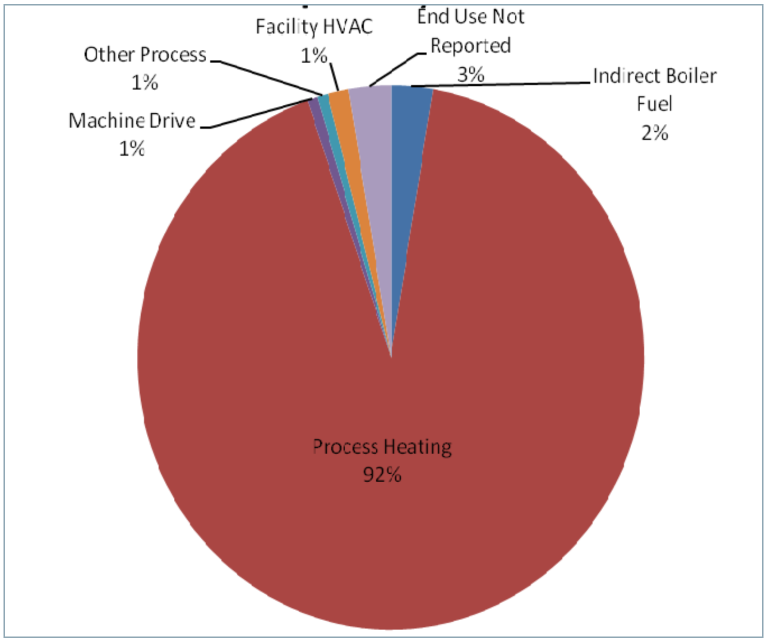
Source: 2006 Manufacturing Energy Consumption Survey

Figure 13 presents the electric energy efficiency potential by end-use for the non-metallic mineral products industrial sectors (NAICS 327), of which gypsum and other mineral product (i.e., lime) manufacturers are a part.[37] The largest potential for electric energy savings lies in pumps and motors, accounting for 33 percent and 23 percent respectively of the total energy savings potential in the non-metallic industry. Given that pumps and motors are also the two largest electric end uses within the gypsum products industry, exploring related efficiency measures presents the greatest opportunity for large-scale energy and utility bill savings.

---

[37] KEMA and Lawrence Berkeley National Laboratory, 2005. California Statewide Industrial Sector Energy Efficiency Potential Study. Prepared for Pacific Gas and Electric Company.

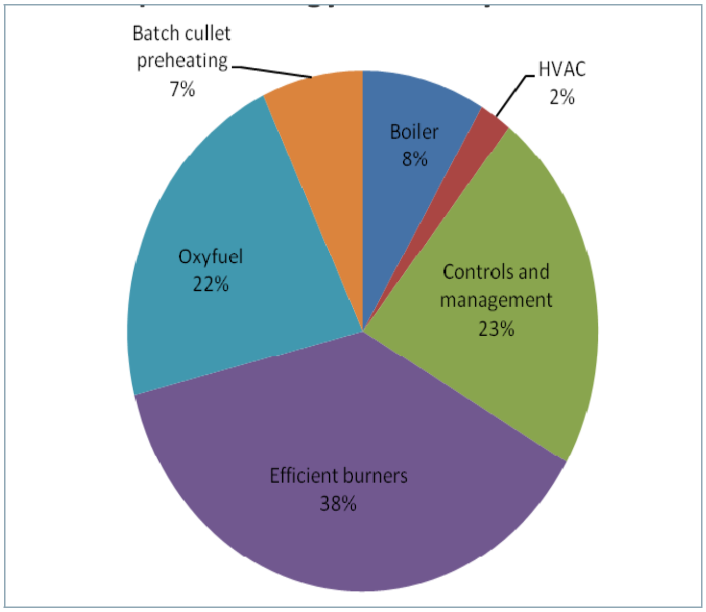
Figure 14: Gypsum Products Industry: Gas Consumption by End Use



Source: 2006 Manufacturing Energy Consumption Survey

Figure 14 breaks down the end-use consumption of natural gas for the gypsum products industry. The overwhelming majority of natural gas is used for process heating, which primarily represents the kiln (92 percent).

Figure 15: Non-Metallic Mineral Products (NAICS 327): Gas Energy Efficiency Potential



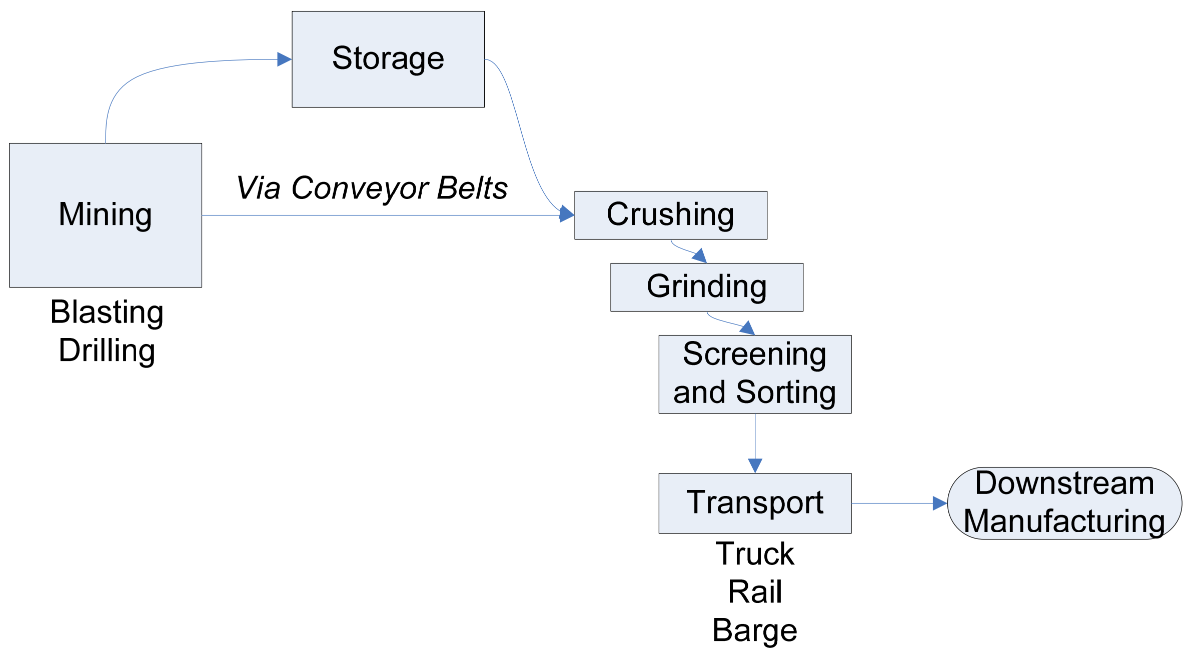
Source: 2006 Manufacturing Energy Consumption Survey

Figure 15 displays the energy efficiency potential related to natural gas use within the non-metallic mineral products industrial sectors (NAICS 327), of which gypsum and other mineral product (i.e., lime) 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 gypsum and lime product manufacturers. For other mineral product manufacturers, controls and management and boiler improvements are the largest opportunities.

4.2.1 Upstream and Downstream Processes

For most mineral products, the production process can be broken into two parts, the part upstream from the factory and the part within and downstream from the factory. The upstream phase—consisting of mining, crushing, sorting, and transport to the factory (Figure 16)—is essentially the same for all mineral products. Vertically integrated companies engage directly in all these activities directly, but all mineral product manufacturing begins with mining or quarrying, usually of low-value, common materials (e.g., clay, limestone, etc.). After mining, minerals are either stored or taken directly, often via conveyer belts, for crushing, grinding, and sorting. The upstream phase ends with transport to the factory.

Figure 16: Upstream Process Common to Mineral Products



Source: Developed by KEMA based on DOE and EPA sources[38],[39]

Companies which engage solely in the upstream part are classified as mining operations and are not part of the mineral product manufacturing industry.

Figure 17 shows two examples of electricity end-use breakdown in the upstream phase excluding conveyer belts: one for cut stone quarrying and one for limestone quarrying from Efficiency Vermont.[40] Much of the energy use in the upstream phase of production goes to pumps, compressed air for drilling, and crushing and cutting equipment. Dust management also drives significant energy consumption for operations with crushed stone. Although not included in Figure 12, conveyers consume a proportion of energy commensurate with the size of the upstream operation. Large operations can have conveyers that stretch for miles and require significant energy. Smaller, more localized operations may have only a few conveyers with

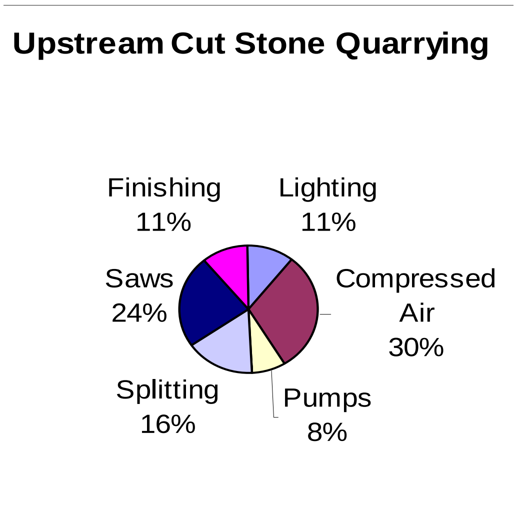
[38] Mining Industry of the Future. 2000. *Mineral Processing Technology Roadmap*. Sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies. September 2000.

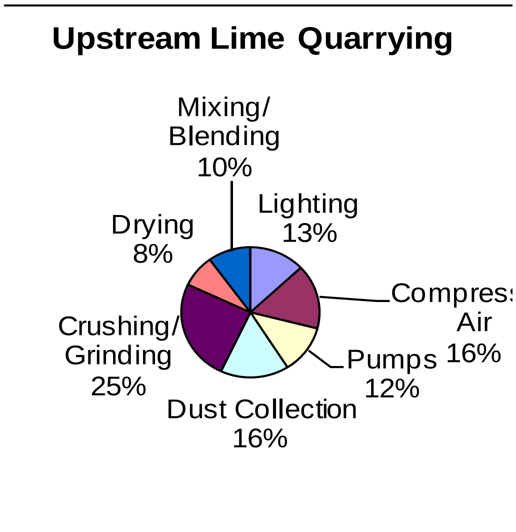
[39] U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards. 1995. "Mineral Products Industry." Chap. 11 of Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42. Fifth Edition. January 1995.

[40] Efficiency Vermont. *Reduce Energy Use at Quarries, Mineral Processing Plants & Gravel Crushing Facilities*. Informational brochure. Date unknown.

http://www.efficiencyvermont.com/stella/filelib/EVT_miningtechFinal.PDF proportionally insignificant energy draw when compared with crushing, dust control, or compressed air. Producers also use significant energy in drilling and transport (including conveyers) for the upstream phase, but it is not included in the above pie charts. Data on end use is not widespread because vertically integrated minerals companies rarely release data categorized by end use and mining specific data is rarely focused on mineral products.

Figure 17: Breakdown of Energy End Use for Upstream Mineral Processing



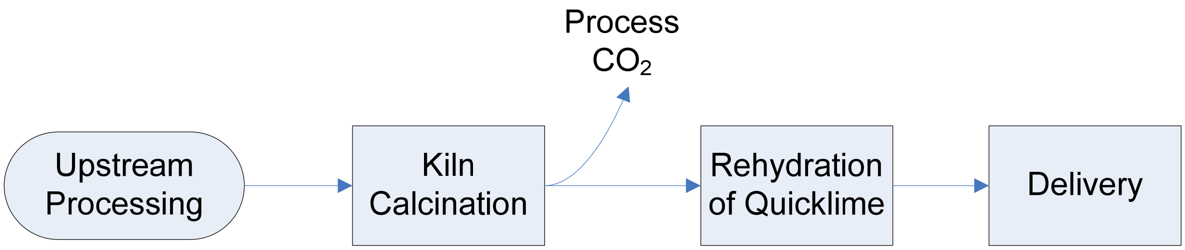


Source: Efficiency Vermont[41]

The second part of the manufacturing, the downstream, in-factory portion, differs for each product. Three examples—lime, gypsum, and clay tiles—give a sense of typical manufacturing processes for mineral products. Figure 18 shows downstream lime processing.

[41] Data from Efficiency Vermont

Figure 18: Downstream Lime Manufacturing Process



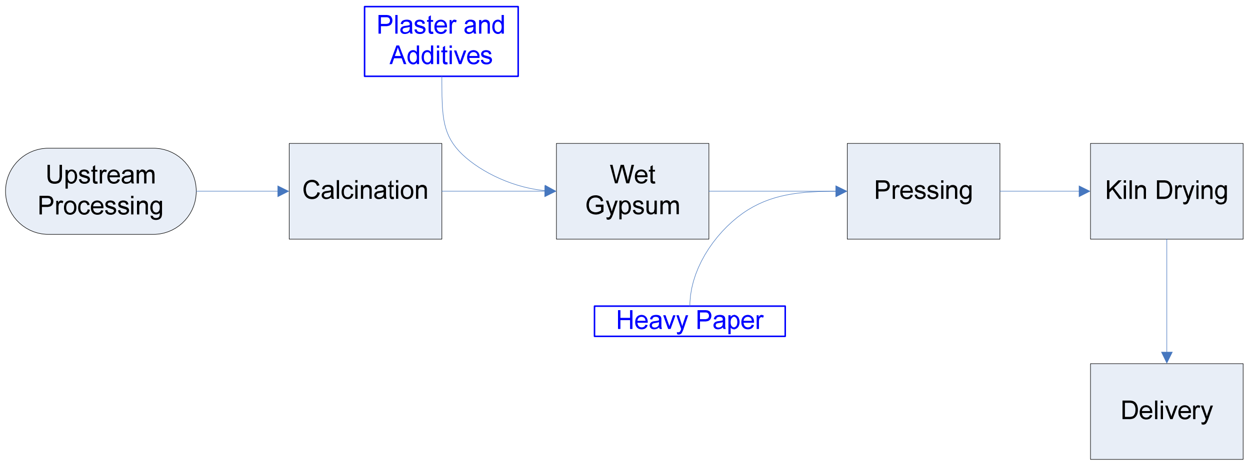
Source: Developed by KEMA based on DOE and EPA sources[42],[43]

Downstream lime manufacturing has relatively few steps because the value added from factory processing is proportionally small but is among the more energy-intensive processes. The key step is transformation from mineral limestone (calcium carbonate [$CaCO_3$]) into lime (calcium oxide [CaO]) through a process called calcination. Calcination consists of kiln heating to around 1,000 degrees Celsius to liberate carbon dioxide at a temperature below the melting point of the mineral. This produces a product known as quicklime, which is rehydrated (hydrated lime; $Ca(OH)_2$) for many applications. The heating associated with calcination is the process step responsible for making lime production energy intensive and also the step that releases CO_2 into the atmosphere. According to the MECS, much of the energy for calcination comes from coal, which can be explained by continued prominence of the traditional coal-fired kiln among lime manufacturers.

[42] Mining Industry of the Future. 2000. *Mineral Processing Technology Roadmap*. Sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies. September 2000.

[43] U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards. 1995. "Mineral Products Industry." Chap. 11 of Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42. Fifth Edition. January 1995.

Figure 19: Downstream Gypsum Wallboard Manufacturing Process



Source: Developed by KEMA based on DOE and EPA sources[44],[45]

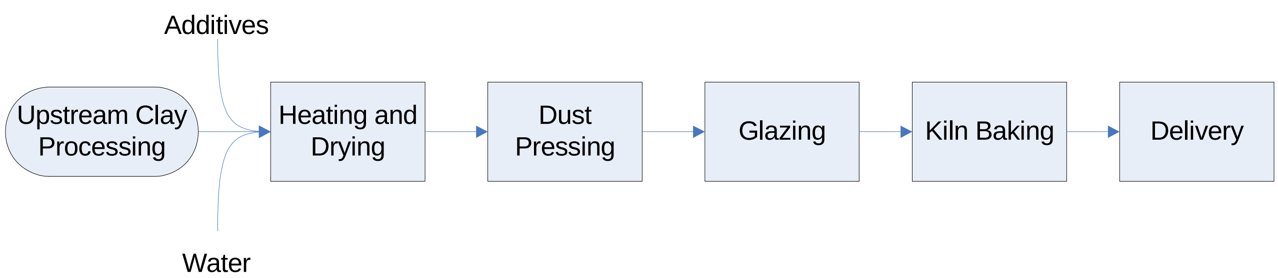
Figure 19 shows the downstream gypsum wallboard production process. Gypsum processing does not require the same amount of energy as lime processing because processing requires breaking weaker chemical bonds. Whereas lime calcination releases CO_2, gypsum calcination (the same term is used, although the chemistry is different) takes mineral gypsum ($CaSO_4 \cdot 2H_2O$) and liberates water as steam, leaving gypsum plaster ($CaSO_4 \cdot (1/2)H_2O$). This dehydration process requires significantly less energy because temperatures are much lower, typically only a few hundred degrees Celsius. Since only steam is released as part of the processing, there are not the same GHG considerations as with lime manufacturing. The remainder of wallboard production consists of adding binders and additives which confer desirable properties to the final product, rolling the mix between layers of heavy paper, pressing, and drying. Again, the drying process is primarily just to relieve the product of excess water and requires very mild heating. Unlike lime manufacturers, the MECS survey indicates that gypsum manufacturers use no coal and instead rely on natural gas.

---

[44] Mining Industry of the Future. 2000. *Mineral Processing Technology Roadmap*. Sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies. September 2000.

[45] U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards. 1995. "Mineral Products Industry." Chap. 11 of Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42. Fifth Edition. January 1995.

Figure 20: Downstream Ceramic Tile Manufacturing Process



Source: Developed by KEMA based on DOE and EPA sources[46],[47]

Finally, Figure 20 shows ceramic tile downstream processing. The ceramic tile manufacturing process is more typical of mineral product manufacturing processes that do not require any chemical changes needed of the kind necessary for lime or gypsum. For ceramic tiles, clay is bound with additives using water, which is then dried to create a dust with the desired properties of the tile. It is pressed into the basic tile shape, glazed to create the desired tile surface, and finally baked into final form. The baking process is the most energy-intensive part of the manufacturing process, but the energy used depends on the type of kiln used. Baking times can range from an hour to a couple of days and temperatures vary depending on the tile, glaze, and kiln but are usually in the range of 900 to 1,300 degrees Celsius.

In general, the amount of energy used and fuel source depend in part on whether the mineral product requires calcination, drying, baking, or some combination of these heating processes. For instance, lime and gypsum manufacturing segments in California each use similar amounts of electricity, but gypsum manufacturers use natural gas for calcination, whereas lime manufacturers more typically use coal. Brick and tile manufacturing requires baking, leading to much higher energy use than cut stone product manufacturing. These important process differences help define the best efficiency targets.

[46] Mining Industry of the Future. 2000. *Mineral Processing Technology Roadmap*. Sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies. September 2000.

[47] U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards. 1995. “Mineral Products Industry.” Chap. 11 of Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42. Fifth Edition. January 1995.

4.2.2 Kilns

The most energy-intensive equipment for lime, gypsum, brick, and ceramic manufacturers is the kiln, but there are significant differences among the types of kilns in use. Understanding the kiln technology in use for different processes is critical to assessing and marketing opportunities in energy efficiency. Each kiln type has different ways efficiency can be incrementally improved.

- **Kettle calciners** are used by gypsum manufacturers who have relatively mild heating needs. In kettle calciners, natural gas burners heat the kettle, in turn heating the gypsum indirectly. The output is released to a hot pit below the kettle. The simplest kettle calciners are used in batch mode, but more sophisticated continuous mode kettle calciners minimize the heating and cooling cycles.
- **Flash calciners**, also used for gypsum, are similar to kettle calciners, except hot gases are applied directly to the gypsum, rather than to a kettle. The gypsum heats quickly and output accumulates at the bottom of the calciner.
- **Shaft kilns**, common in the lime sector, are simple refractory heating devices similar to blast furnaces. Shaft kilns are the least technologically advanced, consisting of a simple shaft heated part way up from the bottom. Lime inputs go in the top and outputs come out the bottom. Fresh air goes in the bottom and exhaust gas out the top. Regenerative kilns pair shafts together and periodically reverse the flow in each to allow a long zone of consistent temperature. Annular kilns heat air in a pressurized internal cylinder which is concentric with the primary shaft, creating countercurrents of air favorable to lime calcination.
- **Rotary kilns** became common for lime calcining in the twentieth century because they allow a much wider range of sizes and quality of raw input than shaft kilns. A tilted horizontal shaft is heated with flows of hot air and slowly rotated. Raw inputs are put in the upper side and output is received at the bottom. Rotary kilns are also sometimes used in gypsum manufacturing. There is much more heat loss with a rotary kiln than in a shaft kiln, but this disadvantage can be mitigated partially through preheating.
- **Fixed hearth kilns** allow for periodic heating and is still used by some industrial clay and ceramic manufacturers. It is a simple downdraft design where heated gases are first forced up through the kiln then down to be exhausted out the bottom, heating a central box in the process. A shuttle kiln is a fixed hearth kiln which has multiple doors and inputs are fed on cars. By shuttling products in and out of a single kiln, manufacturers can minimize time spent on loading and unloading cars.
- **Tunnel kilns** are ubiquitous in the brick industry and common among all types of clay and ceramic manufacturers. Tunnel kilns are continuous kilns, meaning they are

continuously heated. Inputs are loaded onto a series of cars, which move continuously through one or more kiln sections on tracks. Pusher slab, roller hearth, and belt kilns apply the same concept but do not use cars on tracks. Instead, they use conveyer belts, rollers, or special refractory plates which can withstand high temperatures.

4.3 Current Practices

Despite a strong emphasis over the last few years using products to enhance the sustainability of constructed buildings, mineral product manufacturers have not been driven strongly to enhance manufacturing energy efficiency. Operations are substantial simply due to the mass of material being processed and throughput essential. This means that efficiency improvements typically demand a significant capital investment, but because mineral products have a low-value to weight ratio, it takes a large amount of throughput to recoup the investment. The throughput requirements and basic processing involved in mineral product manufacturing mean that most of the industry is best suited to incremental efficiency gains within their existing manufacturing operations.

For certain industrial segments, proprietary technology and processes can hamper information sharing of energy efficient opportunities. This is primarily a concern for some specialty mineral product manufacturers with unique processes to achieve certain finishes, create certain unique products (e.g., photovoltaic roof tiles) or imbue special technical characteristics, as is done with ceramics. In most circumstances, mineral product manufacturing does not rely heavily on proprietary technology.

4.3.1 Efficiency Improvements

Mineral product manufacturers must rely primarily on process improvement, automation, and control technologies to enhance the energy efficiency of their operations. Improvements in the upstream process can help all mineral product manufacturers achieve incremental gains, especially better dust collection, more efficient conveyors, and improved grinding and crushing. The most likely scenario is that the overall efficiency of the upstream production process will improve slowly with time as incrementally more efficient processes are standardized across the energy. Lime, gypsum, and ceramic producers can achieve much greater energy savings though in the downstream phase of production by improving kiln operations and using newer technologies. However, for industries which are not energy intensive and do not use kilns, basic industrial efficiency measures focusing on motors, lighting, and so on are the best avenues to reduce overall energy consumption.

Opportunities for energy efficiency improvements exist in moving to innovative technologies as follows.

Dust Collection

1) Switch from traditional high-pressure (90-100 pounds per square inch [PSI]) pulse jet air cleaning to jet cleaning with medium pressure air (6-12 PSI). According to MAC Technologies, this can result in a 60 percent energy savings when optimized.

2) Re-size dust control equipment to meet the actual operating needs of the operation. Many dust control systems are oversized compared to the flows and static pressures they see in normal operating envelope. This is to prepare for a worst-case scenario, but a comprehensive dust mitigation plan for the worst-case scenario that does not rely entirely on the central system can obviate the need for oversized dust-control equipment. Smaller baghouses need smaller filters and minimize the pressure drop between inlet and outlet, ultimately reducing blower energy use.

Conveyers and Belts

3) Optimize routing using horizontal turns where possible, tunneling (using enclosed pipe conveyers to negotiate tight turns), and use vertical adaptation (e.g., pocket lift systems) when needed. Shorter overall routings require less energy.

4) Use low rolling-resistance rubber for up to 10–15 percent energy savings and variable speed, variable voltage drives for more efficient belt operation.

5) Regenerative drives capture the energy of decelerating loads and feed it back into the system, much like braking on a hybrid car.

Grinding and Crushing

6) Use innovative cone crushers where appropriate. Whereas traditional cone crushers rely entirely on compression, newer models employ proprietary technologies which utilize compression, shearing, and bending. Models like the Kawasaki Cybas may yield up to a 30 percent improvement in energy usage for a similar throughput of crushing.[48]

[48] Prinsloo, L. 2008. “Engineering firm takes on energy challenge.” *Mining Weekly.* July 25, 2008.

7) High-pressure grinding roll (HPGR) technology has been used successfully in the lime and cement industries. As a downstream grinding technology, HPGR grinds rocks between two counter-rotating rollers, allowing the rock to partially crush itself. Total energy consumption has been shown to drop by 20 percent.[49]

Kilns

8) Switch to oxygen-enriched combustion in lime kilns. The U.S. DOE AMO, formerly Industrial Technologies Program, advises using its Process Heating Assessment and Survey Tool to estimate savings from oxygen co-firing.

9) Switch to flash calcining or continuous, rather than batch, kettle kilns for gypsum calcination.

10) In rotary lime kilns, add refractory upgrades including insulated refractory linings, intermediate zone bed tumblers, and discharge end dams to reduce fuel use. Combined, these upgrades can save 1.1–1.5 MMBtu per short ton of lime kilns[50].

11) In tunnel kilns for bricks and technical ceramics, use low-thermal-mass technology with shorter wider cars. Under a California Energy C funded project in the late 1990s, Pacific Clay Building Products saw energy savings of around 30 percent, as well as labor and maintenance cost savings with a low-thermal-mass kiln.[51]

12) For manufacturers who are unable to justify major energy improvements, best practices around energy efficiency center on modifying conveyers and dust collection, making changes to existing kilns, optimizing heat and steam distribution, optimizing compressed air systems, and using lighting more efficiently. Table 7 combines recommendations from the U.S. DOE's Advanced Manufacturing Office, Lawrence Berkeley National Lab, and the Mining Technology Roadmap report.[52],[53]

---

[49] Ibid.

[50] Hanson, G. 2005. "Energy Efficiency Improvement Ideas & Projects for Lime Recovery Kiln Systems." (Metso Minerals presentation to Virginia-Carolina & Southeastern TAPPI Local Sections, Rock Hill, South Carolina, February 17, 2005).

[51] Prinsloo, L. 2008. "Engineering firm takes on energy challenge." *Mining Weekly.* July 25, 2008.

[52] Mining Industry of the Future. 2000. Mineral Processing Technology Roadmap. Sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies. September 2000.

[53] Lawrence Berkeley National Laboratory, Industrial System Optimization. http://industrial-energy.lbl.gov/node/101

Table 7: Best Practices around Industrial Energy Efficiency

Mineral Manufacturing Specific	General Manufacturing Recommendations
Dust Collection *Covered conveyer systems* *Variable speed fans* *Automatic slide gates and/or dampers*	**Heat and Steam** *Improve insulation* *Perform regular maintenance* *Reduce excess air* *Repair leaks* *Recover heat (steam or boiler heat)* *Capture and return hot condensate* *Improve combustion controls*
Conveyers and Belts *Distributed power drive systems* *Optimization of power application* *Coordination of distributed drives* *Design with advanced analysis and simulation tools* *Regenerative drives*	**Compressed Air** *Reduce leaks* *Turn off unnecessary compressed air* *Minimize pressure drops* *Reduce inlet air temperature* *Use air at lowest possible pressure* *Properly size regulators* *Properly size pipes* *Maximize dew point at air intake* *Reduce end use of air with more efficient tools*
Kilns *Partial oxy-fuel conversion* *Optimize batch timing* *Reduce "dead load" of cars and kiln furniture* *Heat recovery to pre-heat combustion air*	**Lighting** *Install lighting controls* *Replace incandescent bulbs with LEDs, CFLs, fluorescent, induction, or high pressure sodium lights* *Install reflectors*

Much of the innovation in mineral product manufacturing is product innovation rather than manufacturing process innovation. Companies invest hugely in facilities to support analytical capability for wet and dry chemistries, X-ray diffraction and scanning electron microscopes, but these are designed to analyze potential new product characteristics. For the highest revenue portions of the industry, process innovation is incremental. Nevertheless, pockets of process innovation do exist.

Ceralink, Inc., a New York-based ceramics firm, won $1.2 million in July 2010 as the top winner in the U.S. DOE's Industrial Energy Efficiency Grand Challenge. Among other activities, the company will establish the manufacturing potential of ultra-rapid, low-energy lamination for ceramics and demonstrate limestone calcination using microwave assist technology—a process combining microwaves with traditional radiant energy for up to 50 percent energy savings. A recent project sponsored by the California Department of Conservation and the Center for Environmental Economic Development investigated introducing recycled glass as a substitute additive in the making bricks. Using recycled glass saved between 30–40 percent of energy used, on per-brick basis, with further savings from the final product being 10 percent lighter.[54] Serious Materials, a Bay Area startup, is producing *EcoRock* gypsum wall board using a novel binder consisting of a proprietary blend of metal silicates, phosphates, and binders. Upon addition of water or acid, the slurry produces an exothermic reaction that obviates the need for calcining or drying. Serious Materials says that production of EcoRock uses 80 percent less energy than producing traditional gypsum wallboard.

4.3.2 Energy Efficient Products

Although separate from manufacturing energy efficiency, nearly all mineral product companies emphasize product characteristics that can enhance end users' energy efficiency. Because mineral products uniquely serve many commercial and residential construction needs, manufacturers have sought to obtain competitive advantage through products which can deliver superior energy efficiency. It has been the focus of significant marketing efforts in the last few years. According to McGraw-Hill Construction Analytics, new government and commercial building codes in California are helping to drive a rise in green-building revenue from $12 billion in 2008 to a projected $60 billion in 2010.Broadly speaking, most companies and trade organizations characterize sustainability as a product feature, rather than as a corporate process objective. For example, GP gypsum emphasizes that the durability of its products make it sustainable, U.S. Tile touts cool-roof tiles that reduce building energy use, H.C. Muddox advertises the thermal mass of bricks compared to stucco, and Gladding McBean specifically discusses Leadership in Energy and Environmental Design certification.

A dynamic favoring product-based energy efficiency is progressive and somewhat unique to building product manufacturers. When approached with industrial process efficiency opportunities, some companies (e.g., GP Gypsum) may initially point towards their product's end-use sustainability characteristics as their primary objective, mitigating the need for investment in process energy efficiency. On the other hand, some companies (e.g., Gladding

[54] Kirby, R. 2006. *Potential Energy Savings from the Use of Recycled Glass in Brick Manufacturing*. Prepared for the Center for Environmental Economic Development and the California Department of Conservation. 2006.

McBean) may view production process energy efficiency as a part of overall product sustainability. Regardless, it is essential to understand that sustainability and energy efficiency tend to have product focus rather than process focus across the mineral product manufacturing industry.

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. KEMA has found that within a sector, responses tend to be fairly similar and a small number of in-depth interviews are sufficient to understand key issues. Interviewees included corporate energy managers and plant engineering and operations staff. To solicit a wide range of opinions, we spoke with representatives from the largest energy consuming manufacturers and smaller manufacturers. Among the largest energy consumers, gypsum and clay were most represented. Our insights and conclusions are presented below.

5.1 Effective Utility Programming

Similar to other industry sectors, respondents were very supportive of utility energy efficiency programs and services. These customers appreciated the financial support and operational assistance through third-party providers to undertake energy efficiency efforts. The following provides more details on these findings.

- *Simplicity*. Customers requested programs that are simple to understand and participate in. Any action that the utility could undertake to facilitate greater customer ease of participation would be well received. This includes increasing promotion of third-party consultants, conducting additional energy audits, and keeping communications simple and direct, whether through email, telephone or in-person.
- *Third-Party Consultants*. Customers interviewed cited satisfaction with these technical service providers and 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.* Respondents participated in a range of utility offerings such as energy audits, rebate programs, and demand response and gave many positive comments about the utility's role in energy efficiency. No respondents identified any programs that should be added, indicating satisfaction with the current program

offerings. For the largest energy users interviewed, demand response programs offered much praised savings for minimal operational disruption. For large capital projects, utility programs can bring the payback period down to levels that make small- to medium-sized projects attractive, but are unlikely to be the determinant for large capital projects.

5.2 Drivers of Energy Decision-Making

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

5.2.1 Energy Efficiency Planning

Cost savings is the largest single driver of energy efficiency projects cited by customers interviewed. This finding reflects messages from similar industrial sectors where energy is not the number one production cost, but still commands interest for relatively easy access to cost savings.

Customers reported low interest in experimenting with new technologies. This finding was true for both large and small customers interviewed. For example, a representative from one large energy consumer in this sector noted that overall low-risk tolerance for energy efficiency strategies and programs is low. One industry veteran noted cyclical industries like gypsum are very risk averse. When times were good and production is high, there is money but no interest in risking production time. When business is slow, it is hard to fund projects.

Table 8 displays manufacturers' self-reported ability to undertake energy efficiency practices or investments. The average self-reported rating was mid-range (number 3 on a scale of 5), meaning that customers interviewed have completed a range of energy efficiency projects and programs, but opportunities still exist. Primarily barriers identified are total project cost, payback, and economic downturn inhibiting any projects. Most customers reported specific projects have been identified that could be completed if the barriers surrounding payback and project cost could be overcome. These opportunities are primarily in basic upgrades and plant improvements such as lighting upgrades, variable-speed drive installations, and motor efficiency. Two customers fell outside this range. One small manufacturer's self-reported rating was number 4, and noted that energy audits would be helpful to understand opportunities and assistance with rebates through a third-party provider would help drive the projects forward. All but one customer interviewed participated in demand response programs, either through the utility or a third-party aggregator. These customers had positive experiences and appreciated the monthly bill savings or additional compensation for shutting down operations when called upon. One customer reported shutting down operations did not significantly disrupt operations since the economic downturn has negatively affected customer demand, meaning their plant was not running at full capacity anyway.

Table 8: Self Reported Manufacturer's Ability to Undertake Energy Efficiency Investments, Using Scale 1–5[55]

Manufacturer Type	Self-Reported Rating: EE Projects Undertaken	Notes
Gypsum	#2	Aggressively seeking energy efficiency since energy has surpassed labor costs.
Gypsum	#4	Many projects are possible: all the lighting; many motors are not high efficiency, improvements in the way motors are started.
Aggregates	#3	More projects are possible if the payback decreases.
Clay	#3	We have 200 hp in the plant. We've talked about what to do. We participated in purchasing new higher efficiency compressor, with variable speed drives. We can change light bulbs, but we think we've done most of that.
Ceramic materials	#3	Not looking at any major projects in this economy due to the cost.

Source: KEMA interviews

Energy efficiency planning varies among companies interviewed, but generally larger firms have more energy staff and technical resources. For example, one large gypsum manufacturer measured daily the kWh per 1,000 square feet of wallboard produced and has an energy dashboard to "show this to the 5th decimal place to the right." This focus on energy translated into an aggressive pursuit of energy efficiency opportunities that provide the most value but are relatively simple to implement, such as rebate programs.

Typically, project ideas are championed by plant managers, engineering employees, or other technical staff, who investigate costs, impact on operations, and overall feasibility. These opportunities are ranked, and submitted to managers for approval. The larger the project, the higher the management approval is needed. For smaller customers, energy efficiency ranks below raw material sourcing and labor as business priorities, but relatively simple opportunities to save money are sought.

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

Customers reported hearing about energy efficiency opportunities from utility representatives, vendors, colleagues, seminars/association meetings, and other sources. Many of the customers had participated in demand response programs for numerous years, and could not specifically recall when or how the decision first originated. Smaller customers were more likely to report the utility representative or third-party provider had suggested projects while larger customers had more resources and staff to investigate multiple sources of opportunities.

For multisite manufacturers, successful energy efficiency projects are typically replicated across facilities. This indicates that utility contact with both the plant staff and corporate level employees may be helpful. For example, a large gypsum manufacturer interviewed reported that the corporate energy manager had attended a utility forum along with plant level staff and found it helpful to understand opportunities. Smaller companies tend to rely on utility representatives, third-party providers or vendors for energy efficiency projects and opportunities.

Project funding is typically from capital budgets for those over $25,000. Smaller projects, typically less than $25,000, can be approved at the plant level. Many of the customers interviewed reported financing is a significant barrier to energy efficiency rebate projects. The economic downturn has inhibited customers' willingness to pursue opportunities, even if the payback falls within the preferred range of under two years. This suggests that the utility can engage customers by keeping it simple and focusing on low cost programs such as continual energy improvements and energy audits to reduce risk-averse behavior.

5.2.2 Investment Priorities

Customers reported strong receptivity to energy savings projects although energy is not the largest investment priority for minerals sector customers. Consequently, customers sought low-risk methods to reduce their energy spend such as short payback periods, using proven technologies, simple program participation, and pursuing projects where energy efficiency is an added, rather than primary, benefit (i.e., equipment replacement).

Large gypsum manufacturers interviewed reported an overall rise in energy awareness, but other business priorities continue to take precedence. These customers are not interested in pursuing *any and all* measures to reduce costs. Smaller manufacturer customers reported that energy ranked below labor and raw materials as business investment priorities and sought the expertise and guidance of third-party providers and energy auditors.

Project payback ranks among top project criteria, and acceptable periods range from a few months to several years. Project payback has not significantly shortened during the economic downturn since this is one among several factors such as financing, impact on operations and availability of credit. Total project cost is important particularly for small manufacturers that reported securing bank loans to fund larger projects. One customer reported that they have not attempted to secure bank loans recently, but have heard that the process has become "impossibly difficult." No customers reported pursuing energy efficiency projects over two years for the cost savings alone.

Table 9 describes payback periods among the minerals sector customers interviewed. Energy efficiency projects with paybacks from one to two years are typical although all customers reported the shorter the payback the more likely the project would succeed. This payback period has declined in the short and long term. One customer reported payback periods up to seven years were acceptable a decade ago. In the current economic climate, projects over two to three years are difficult to approve for energy efficiency savings alone.

Table 9: Payback Periods, by Manufacturer Type

Manufacturer Type	Payback
Gypsum	1 year
Gypsum	2-3 years
Aggregates	2 years
Clay	Depends on project cost not payback
Ceramic materials	1-2 years

Source: KEMA interviews

For large capital projects, incentives will typically not determine whether a project goes forward, but can bring the payback down to acceptable levels. One customer reported a motor-replacement project had not proceeded because current payback is roughly 10 years, but they recently engaged a third-party consultant to seek rebates to lower the payback period. Of particular note is that the customer was not aggressively pursuing projects before the consultant contacted this customer.

5.2.3 Project Financing

Project financing has become a significant barrier during the current economic downturn. The minerals sector major customer segment, construction, has undergone a severe cyclical downturn in California. Minerals sector customers interviewed reported declining revenues and increasing difficulties financing projects. One customer reported that projects need to be planned well in advance to have the best opportunity at securing funding among competing priorities. Customers reported financing projects of any significant size (e.g., > $25,000-50,000) through capital budgets that required layers of management approval. A small manufacturer reported funding all projects through capital reserves. Only one respondent voiced any interest in utility sponsored financing options.

5.3 Cycles of Innovation

Generally, customers in the minerals sector are risk adverse and tend to prefer proven technologies and programs. This is not surprising since energy ranks lower in corporate priority.

As noted in section 4.3.1, innovation in this subsector is more focused on products than processes. Process innovation may include sophisticated monitoring and 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.

One forum participant noted that international gypsum manufacturers, with higher energy costs and less cyclical production, are known to be less risk averse and more likely to invest. Outside the United States, corporations are more willing to invest in bigger projects with more risk. Global companies also have the opportunity to benchmark processes for approval and then implement these good ideas at multiple facilities.

Education plays a significant role in driving innovation acceptance. Proposing relevant energy efficiency options and tailoring the message to the customer’s risk tolerance is critical. Some strategies that are industry accepted are considered too innovative and risk for others. For example, a small manufacturer reported that shutting down operations would never be a viable option, no matter what compensation is offered, and considered it an unproven technology. Understanding what the customer knows about innovative technologies and programs, and how they perceive innovation, is key to helping them understand which programs can be successful for them.

For existing products, the 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. In subsectors tied to the building industry, green codes and requirements are expected to drive innovation.

Existing plants require ongoing maintenance and replacements to remain operational. Recent implemented projects cited by customers include: upgrading/replacing lighting and HVAC systems, upgrading motors to higher efficiency, installing variable frequency drive controls on motors and fans, and replacing worn or outdated process equipment. These recent projects indicate that companies have remaining potential energy performance improvement, and new energy efficiency projects can be found if these customers would be willing to consider the next tier of options.

5.4 Customer Assessment

Customers interviewed stated they would consider 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

More than half of the customers interviewed rated their program awareness as moderate to low, indicating an opportunity for the utility to further engage customers in this sector. These customers spanned sectors of gypsum, clay, and minerals. Educational efforts mentioned as helpful included more frequent utility representative contact by email as a check-in and additional sector-specific webinars/forums. A manufacturer reported that program information typically came from sources other than the utility (e.g., colleagues and vendors), and it would be helpful for utility to reach out directly. The remaining customers reported awareness levels as relatively high, but when asked if more information was needed, one large manufacturer requested that the contact them more often to tell us about these programs.

Utility program awareness varied by customer size: the higher the customer's energy usage, the more likely the customer understood the programs. For example, one large manufacturer reported high levels of program awareness and maintained frequent contact with their utility representative. By contrast, the smaller manufacturers interviewed all reported moderate to low awareness. For centralized companies, one energy manager may operate across many utility territories. In these cases, the customer may have sophisticated knowledge of energy efficiency and utilities programs in general, but may not have deep understanding of a particular utility's offerings.

5.4.2 Customers' Experience

All customers interviewed had participated in the California utilities' industrial programs and praised the incentive/payment levels, relative ease of participation, and ability to undertake projects by lowering the payback period. Customers unanimously replied that program participation hinged on the most key criteria of payback. Thus, program type was less important than the anticipated savings.

Several participants worked with third-party firms and reported positive experiences, although less enthusiastically than customers in other sectors such as cement and concrete. These firms conducted energy audits and handled rebate applications and savings estimations.

Customers were most interested in rebate programs and demand response but would consider any program or opportunity that saves enough money to make participation worthwhile. Projects are typically financed using capital budgets although some customers reported using operations budgets or cash reserves for smaller projects, typically under $25,000-$50,000.

Customers did report some criticism that hinged primarily on education. For example, one customer reported confusion about how demand charges are calculated and was unclear on whether shutting down operations upon utility request would save money, or whether shifting to off-peak would save money.

Customers reported satisfaction with auditors' level of knowledge and expertise. Mineral sector experience was not a factor in customers' satisfaction. Customers in this sector are more likely to pursue projects consistent with typical utility offerings rather than sector-specific processes. This suggests opportunities for sector-specific projects such as those described in section 4.3.1.

6. Next Steps and Recommendations

This investigation has revealed that minerals 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. **Encourage Low-cost Improvements.** Companies in the minerals sector 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.
2. **Build on Customer’s Internal Goals and Programs.** The most sophisticated customers have an established internal energy efficiency program and monitor energy costs closely. 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.
3. **Engage in Additional Customer Outreach and Education.** Customers would be receptive to additional educational efforts to better understand program options, based on the interviews conducted. Because the minerals industry is comprised of numerous smaller manufacturers engaged in a variety of different subsectors, reaching each customer individually is difficult. Increasing established approaches such as email, live, telephone or on-line forums, and newsletters can bridge the knowledge gap in program understanding.
4. **Keep it Simple.** Most customers seek proven innovations and technologies and are risk adverse in energy efficiency, particularly during the economic downturn. Customer communications can be kept simple and on message about saving money, at the least disruption to the customer’s operations.
5. **Identify Planned Upgrades and Document Associated Efficiency Opportunities.** Despite the economic downturn, 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 customers 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.

6. **Increase Promotion of Third-Party Providers.** Customers accepted third-party providers' role for simplifying the program process, and removing barriers such as lack of staff time and paperwork requirements.
7. **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 the California 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.** A few highly sophisticated customers may be potential candidates for programs leading to certification under ISO 50001 or the DOE's Superior Energy Performance. Other firms that are less engaged may be receptive to shorter term continual improvement programs like the Energy Trust of Oregon's (ETO) *Kaizen Blitz* pilot program[56] and the Puget Sound Energy's Resource Conservation Manager Program.[57] The ETO program offers an initial audit and one year of technical assistance but requires the participants to set goals and implement fast payback options. The PSE program offers grants for a

[56] Navigant. 2010. *Kaizen Blitz Pilot, Report One*. Prepared for Energy Trust of Oregon. October 2010 http://www.affiliatedrecon.com/studies/OR/Energy_Trust/General/ETO-Kaizen-Blitz-Pilot.PDF

[57] Puget Sound Energy. *2010 Business Energy Management, Resource Conservation Manager Program*. February 2010.
http://www.pse.com/savingsandenergycenter/ForBusinesses/Documents/3462_RCM.PDF

resource conservation manager, and incentives for energy efficiency improvements. This program focuses on and rewards improvements in behavior and utility cost accounting.

3. **Combine Energy Efficiency Offerings with Development of New Products.** New products, often developed to support green building practices, drive innovation more than processes. Utilities can look for synergies with the commercial building sector to support energy efficient manufacturing of these products. Products with a lower carbon footprint are more attractive in the green building sector.
4. **Engage the Uninterested in Measurement.** One of the biggest challenges in the industrial sector is increasing participation, particularly when market concentration is low as it is for several sub-segments in the minerals industry. 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 in specific process areas, such as kilns, grinding and sizing equipment and conveyors.

7. References

Ahrens, M. and S. Southby. 2010. "Cutting edge, energy efficient conveyer systems." *Australian Bulk Handling Review*, March/April, 2010.

Alspaugh, M.A. 2004. "Latest Developments in Belt Conveyor Technology." (Presented at MINExpo 2004, Las Vegas, NV, September 27, 2004).

Althouse, M. and N. Egbert. 2009. *Dust Collection Design: Incorporating Safety, Performance, and Energy Savings*. MAC Equipment White Paper, 2009.

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. http://www.aceee.org/files/pdf/fact-sheet/ACEEE-Barriers_to_industrial_EE_10-20-09.PDF

American Council for an Energy Efficient Economy. 2009. *Trends in Industrial Energy Efficiency Programs: Today's Leaders and Directions for the Future*. September.

American Council for an Energy Efficient Economy. 2011 National Symposium on Market Transformation. http://www.aceee.org/conferences/2011/mt/program

Aumann, D. 1999. *Low-Thermal-Mass Kiln Installation at Pacific Clay Products, Inc: Analysis of Business, Energy, and Environmental Issues*. Pacific Clay Products for California Energy Commission and U.S. Department of Energy, August 31, 1999.

California Institute for Energy and Environment. 2009. *Behavioral Assumptions Underlying Energy Efficiency Programs for Businesses.* January 2009. http://uc-ciee.org/downloads/ba_ee_prog_bus_wp.PDF

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

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.

Efficiency Vermont. *Reduce Energy Use at Quarries, Mineral Processing Plants & Gravel Crushing Facilities*. Informational brochure. Date unknown. http://www.efficiencyvermont.com/stella/filelib/EVT_miningtechFinal.PDF

Entec, Inc. 2006. "Gypsum." Chap. 7 of *Defra EU ETS Phase II – UK New Entrants, Final Report*. For the British Department of Trade and Industry. March 2006.

European Environment Agency (EEA) and European Monitoring and Evaluation Programme (EMEP). 2009. "Lime Production." Part B: Chap. 2.A.2 of *EMEP/EEA air pollutant* *emission inventory guidebook 2009, Technical guidance to prepare national emission inventories*. EEA Technical report No 9/2009. June 19, 2009.

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

Gas Technology Institute. 2010. "Natural Gas Advancements for Industrial Customers." *Pipeline and Gas Journal*, April 2010 Vol. 237 No. 4.

Hanson, G. 2005. "Energy Efficiency Improvement Ideas & Projects for Lime Recovery Kiln Systems." (Metso Minerals presentation to Virginia-Carolina & Southeastern TAPPI Local Sections, Rock Hill, South Carolina, February 17, 2005).

IBISWorld Industry Reports, 2009 and 2010.

Imeläinen,H., M. Loukiala and U. Launonen. 2005. "Lime Kiln Optimisation: Managing the Inputs to Stabilise the Outcome." (Presented at the 59t[h] Appita Conference, Auckland, New Zealand 16-19 May 2005).

KEMA and Lawrence Berkeley National Laboratory, 2005. *California Statewide Industrial Sector Energy Efficiency Potential Study*. Prepared for Pacific Gas and Electric Company.

Kirby, R. 2006. *Potential Energy Savings from the Use of Recycled Glass in Brick Manufacturing*. Prepared for the Center for Environmental Economic Development and the California Department of Conservation. 2006.

Lawrence Berkeley National Laboratory, Industrial System Optimization. http://industrial-energy.lbl.gov/node/101

McGinnis, M. and D. Llagunao. 2002. "Low-Mass Kiln Furniture." *Ceramic Industry.* February 1, 2002.

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

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

Miller, M. 2001. *U.S. Geological Survey Minerals Yearbook—2001: Volume I—Metals and Minerals, Lime.*

Mining Industry of the Future. 2000. *Mineral Processing Technology Roadmap*. Sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies. September 2000.

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

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

Naud, S. and M. Emond. 2007. "Lime kiln control using simple advanced regulatory control strategy." (Presented at the Annual Meeting of the Pulp and Paper Technical Association of Canada, 2007).

Navigant. 2010. *Kaizen Blitz Pilot, Report One*. Prepared for Energy Trust of Oregon. October 2010 http://www.affiliatedrecon.com/studies/OR/Energy_Trust/General/ETO-Kaizen-Blitz-Pilot.PDF

Northwest Energy Efficiency Alliance. Continuous Improvement for Industry website. http://www.energyimprovement.org/index.htmlKirby, R. 2006. *Potential Energy Savings from the Use of Recycled Glass in Brick Manufacturing*. Prepared for the Center for Environmental Economic Development and the California Department of Conservation. 2006.

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

Pilko, C. 2003. "Kilns 101: Understanding the Different Kiln Types." *Ceramic Industry.* May 1, 2003.

Prinsloo, L. 2008. "Engineering firm takes on energy challenge." *Mining Weekly.* July 25, 2008.

Puget Sound Energy. *2010 Business Energy Management, Resource Conservation Manager Program*. February 2010. http://www.pse.com/savingsandenergycenter/ForBusinesses/Documents/3462_RCM.PDF

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

Savitz, et al. 2009. *DOE Industrial Technologies Program 2008 Peer Review*. http://www1.eere.energy.gov/industry/about/pdfs/itp_peerreview_report2008.PDF

Taylor, Mac. 2011. *Letter to Honorable Dan Hogue*., California Legislative Analyst's Office. May 13, 2011. http://www.lao.ca.gov/reports/2010/rsrc/ab32_logue/ab32_logue_051310.PDF

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

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

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

U.S. Census Bureau. 2008. *2006 Annual Survey of Manufacturers*. November 18, 2008.

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Industrial Technologies Program. 2002. *Combined Heat & Power: Cost Reduction Strategies*. Factsheet, January 2002. http://www1.eere.energy.gov/industry/glass/pdfs/chp.PDF

U.S. Department of Energy, Energy Efficiency and Renewable Energy. 2010. *Energy Technology Solutions, Public-Private Partnerships Transforming Industry*. December 2010. http://www1.eere.energy.gov/industry/pdfs/itp_successes.PDF

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

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.2002. "Crushed & Broken Limestone and Other Crushed Rock." Chap. 9 in *Energy and Environmental Profile of the U.S.* December 2002.

U.S. Department of Energy. 2008. *Combined Heat and Power: Effective Solutions for a Sustainable Future*. Prepared by Oak Ridge National Laboratory, ORNL/TM-2008/224, December 2008.

U.S. Department of Energy. 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

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

U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards. 1995. "Mineral Products Industry." Chap. 11 of Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. AP-42. Fifth Edition. January 1995.

U.S. EPA, Office of Air and Radiation, Office of Air Quality Planning and Standards. 1995. "Mineral Products Industry." Chap. 11 of *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*. AP-42. Fifth Edition. January 1995.

U.S. Geological Survey. 2011. Mineral Commodity Summaries, Gypsum. Reston, Virginia. January 21, 2011.
Accessed at: http://minerals.usgs.gov/minerals/pubs/commodity/gypsum/mcs-2011-gypsu.PDF

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

XENERGY. 1998. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Prepared for Oak Ridge National Laboratory and DOE's Office of Industrial Technologies.

A. Attachments

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

1. What are the major factors your company considers when deciding whether to participate in a utility-sponsored program?
2. 2. What type of utility sponsored program(s) are you most likely to participate? Least likely? Has this shifted over time? If so, why?
3. Does your utility offer energy efficiency and/or energy management programs that address your important energy concerns?
    a. If not, what is missing?
4. 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,

a. What is the most effective and beneficial energy efficiency program you have participated in? Please explain what you found beneficial.
b. 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?
c. Did participating meet your expectations?
    i. If yes, how?
    ii. If not, why not?
d. 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.

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?