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LIME

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Lime

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The U.S. lime industry is characterized by high barriers to entry, which include an industry dominated by a few large-scale producers with nationwide supply and distribution networks, a scarcity of high-quality limestone deposits on which the required zoning and mining permits can be obtained, the need for lime plants and facilities to be located close to markets with access to suitable transportation networks to allow for cost-effective production and distribution, environmental regulations making it more difficult to obtain permitting for new lime kilns, and the high capital cost of the plants and facilities. As an example, there has been only one new U.S. lime plant (Verona, KY) constructed in the past 20 years by a company from outside the lime industry, and it was acquired by one of the leading lime companies during its first year of operation.

In 2012, the U.S. lime industry (including that in Puerto Rico) comprised 31 companies, included 20 companies that "sold" lime products and 11 companies that produced lime that was "used" for internal company purposes. Owing to its reactivity and short shelf life, lime is not stockpiled in large amounts and data on stocks were not collected. On an annual basis, the amount of lime "sold and used" (synonymous with production) and consumed are considered to be equal. Lime is a basic chemical produced as quicklime in 29 States and Puerto Rico. In 2012, lime production in the United States was 18.8 million metric tons (Mt), a decrease of 283,000 metric tons (t) from that of 2011. The value of U.S. lime production was $2.23 billion (table 1). Lime sold and used decreased in all major market sectors; in descending order, the decreases (based on unrounded data) were environmental (141,000 t), metallurgical (88,000 t), chemical and industrial (53,000 t), refractories (9,000 t), and construction (4,000 t). Despite the slight decrease in production and sales, lime prices on average increased by $7 per metric ton.

The term lime as used throughout this report refers primarily to six chemicals produced by the calcination of high-purity limestone or dolomite followed by hydration where necessary. There are two high-calcium forms of lime—high-calcium quicklime (calcium oxide, CaO) and high-calcium hydrated lime [calcium hydroxide, $Ca(OH)_2$]. There are four dolomitic forms—dolomitic quicklime ($CaO \cdot MgO$), dolomitic hydrate type N [$Ca(OH)_2 \cdot MgO$], dolomitic hydrate type S [$Ca(OH)_2 \cdot Mg(OH)_2$], and refractory dead-burned dolomite ($CaO \cdot MgO$). The terms "type N" and "type S" refer to "Normal hydrated lime" and "Special hydrated lime" that are differentiated primarily by the compounds' plasticity (ability to retain water) and oxide content. There are also air-entrained versions of these hydrates designated as "type NA" and "type SA."

At present, all commercially produced lime in the United States is manufactured from limestone or dolomite, but lime also can be produced from a variety of calcareous materials, such as aragonite, chalk, coral, marble, and shell. It also is regenerated (produced as a byproduct) by paper mills, carbide plants, and water-treatment plants. Regenerated lime, however, is beyond the scope of this report.

Legislation and Government Programs

Beginning in 2010, the U.S. Environmental Protection Agency (EPA) required large emitters of greenhouse gases (GHG), including lime plants, to collect and report GHG emissions data. In 2010, the EPA issued a final rule ''tailoring'' its New Source Review (NSR) permitting and Federal Operating Permit (FOP) programs to apply to facilities with certain thresholds of GHG emissions. The first phase of the ''tailoring rule,'' known as Step 1, required existing facilities subject to Federal NSR for pollutants other than GHG to include GHG in their permits if GHG emissions will increase by 75,000 short tons per year or more beginning January 2, 2011. In July 2011, Step 2 of the tailoring rule extended NSRs and FOPs to new sources that emit or have the potential to emit at least 100,000 short tons per year carbon dioxide equivalent (CO_2-eq) or existing sources that emit at that level and that undertake modifications that increase emissions by at least 75,000 short tons per year CO_2-eq. In 2012, the EPA issued its final regulation for Step 3 of the tailoring rule, whereby it decided to retain the Step 2 applicability thresholds (U.S. Environmental Protection Agency, 2012, p. 1–5). Thus, any new facilities or major modifications to existing facilities that exceed the federal NSR emission thresholds will be required to use ''best available control technology'' and energy efficiency measures to minimize greenhouse gas emissions. The implementation of the tailoring rule to NSR permitting could result in increased time and costs of plant upgrades and expansions by the lime industry.

Production

Domestic production data for lime were derived by the U.S. Geological Survey (USGS) from a voluntary survey of U.S. operations. The survey was sent to primary producers of quicklime and hydrate, but in order to avoid double counting, it was not sent to independent hydrators that purchase quicklime for hydration. Quantity data were collected for 28 specific and general end uses, and value data were collected by type of lime, such as high-calcium or dolomitic. In 2012, of the 90 operations that were canvassed, data were received for 86 operations including 6 that were idle during the year. Data received represented 97% of the total lime sold or used by producers listed in tables 1–5. Production data for the nonrespondents were estimated based on prior-year production data and other information.

During 2012, quicklime was produced at 76 lime plants, and included 31 plants with collocated hydrating plants. Hydrated

lime also was produced at 14 standalone hydrating facilities, including 3 plants where the kilns had been shut down and hydrate was manufactured from quicklime produced offsite. These numbers do not necessarily agree with the number of plants reported in table 1 because, for data collection purposes, some company operations have been combined at the respondent's request. In a few States with no quicklime production, hydrating plants used quicklime shipped in from other States. There were also a substantial number of slurry plants where lime was converted to liquid form by the addition of water prior to sale; this product is sometimes called milk-of-lime. In addition to stationary slurry plants, there were mobile hot lime slurry production systems designed to slake quicklime or slurry hydrated lime to the percent solids required for each job.

Data on lime sold or used in the United States formerly were shown in table 2 by State (with some regional groupings of States). However, owing to industry consolidation and the need to protect company proprietary data, data on lime sold or used in the United States are now shown in table 2 by U.S. Census Bureau region. In 2012, States with production exceeding 2 Mt were, in descending order, Missouri, Alabama, and Kentucky; States with production between 1 and 2 Mt were, in descending order, Ohio, Texas, Nevada, and Pennsylvania.

Total lime sold or used by domestic producers in 2012 was 18.8 Mt (table 1), a slight decrease compared with that of 2011. Production included the commercial sale or captive consumption (described by the term "used") of quicklime, hydrated lime, and dead-burned refractory dolomite. Data were incomplete on the production of hydrated lime because some producers do not report data on downstream hydrating plants. Traditionally, most U.S. lime production sold and used is in the form of high-calcium quicklime. In 2012, production of high-calcium quicklime decreased slightly to 13.6 Mt while dolomitic quicklime production increased slightly to 2.71 Mt. The production of high-calcium hydrate was essentially unchanged. Production of dolomitic hydrate increased by 3%, but production still has not recovered to levels seen prior to the 2008–09 recession. Commercial sales of quicklime and hydrate decreased to 17.5 Mt, and captive consumption decreased to 1.34 Mt.

At yearend, the top 10 companies were, in descending order of U.S. lime production, Carmeuse Lime and Stone, Lhoist North America, Graymont Ltd., Mississippi Lime Co., United States Lime & Minerals, Inc., Martin Marietta Magnesia Specialties LLC, Unimin Corp. (doing business as Southern Lime Co.), Cheney Lime & Cement Co., ArcelorMittal USA Inc., and Greer Lime Co. These companies reported production from 41 lime plants and 12 separate hydrating plants and accounted for nearly 93% of the combined commercial lime sales and nearly 89% of total lime production.

Graymont Ltd. acquired Western Lime Corp. and its three lime plants—Eden, WI; Green Bay, WI; and Port Inland, MI—increasing Graymont's presence in the Midwest (Graymont Ltd., 2012c). The newly acquired plants were added to the Graymont Western U.S. Inc. division, which includes plants in Montana, Nevada, Oregon, Utah, and Washington. Graymont's other U.S. lime plants include Graymont Dolime (OH) Inc., Graymont (PA) Inc., and Graymont (WI) LLC. In related news, Graymont announced that it was conducting an exploration program in Michigan's Upper Peninsula (same general area as the company's Port Inland plant) to identify suitable new limestone resources. The exploration program was being conducted in the eastern part of the Upper Peninsula southeast of Newberry, MI. The project site would cover an area of about 2,020 hectares (ha) (5,000 acres), but the active quarry and buffer areas would only cover about 324 ha (800 acres) at any point in time (Graymont Ltd., 2012a). Graymont also began its project to expand lime production capacity at its Pleasant Gap, PA, lime plant. Pending approval of its application to the Pennsylvania Department of Environmental Protection, the company intends to install a vertical shaft parallel flow regenerative lime kiln. The project would include installation of the natural-gas-fired kiln rated at 600 metric tons per day (t/d) with 2 diesel-fired emergency generators, and improvements to limestone and lime storage, handling, and loading operations. Addition of the new kiln would increase the plant's capacity by 25% (Graymont Ltd., 2012b; Pennsylvania Department of Environmental Protection, 2012).

Martin Marietta Magnesia Specialties LLC completed an expansion project at its Woodville, OH, lime plant, which included installation of a coal-fired preheater rotary kiln with a complete dust collection and air handling system, and construction of additional product storage and load-out capacity. The new kiln has the capacity to produce 816 t/d and is the sixth kiln at the facility, which produces dolomitic quicklime that is mainly sold for use in steelmaking and as feedstock to produce magnesia (Martin Marietta Magnesia Specialties LLC, 2012).

Lhoist North America installed a hydrator at its lime plant at Ste. Genevieve, MO. The new equipment included lime hydration equipment and associated conveying, milling, screening, storage, and load-out equipment. The new hydrator will produce Lhoist's specialty hydrate product, Sorbacal SP, which is used in dry-process flue gas treatment systems. The new hydrator was expected to start operating in the spring of 2013 (McIlvaine Company, The, 2013).

Carmeuse Lime & Stone announced plans to install two gas-fired vertical shaft kilns at its Clear Brook plant near Winchester, VA, pending approval of its air permit by the Virginia Department of Environmental Quality. The kilns each will have a capacity to produce 400 t/d and combined will double the plant's previous operating capacity. The company's Clear Brook quarry has sufficient reserves for 40 to 50 years after Frederick County rezoned about 37 ha (92 acres) from rural to extractive manufacturing (Voth, 2012).

A number of plants that shut down during the 2008–09 recession remained idle for all or the majority of 2012. These included five Lhoist North America plants (Alabaster, AL, Douglas, AZ, Tenmile, ID, Grantsville, UT, and the hydrating plant at Belen, NM) and two Carmeuse Lime & Stone plants (South Chicago, IL, and Clear Brook, VA). Some of these plants are quite old and may never reopen, at least in their current form.

Consumption

The USGS does not collect lime value data by end use, but in prior years estimated value data were displayed in tables 3 and 4. These estimated values were based, in most cases, on the

average value per ton of all types of lime. Tables 3 and 4 now only display quantities of lime sold and used for various uses.

In 2012, U.S. lime consumption decreased slightly in all major market sectors. The breakdown of lime consumption by general end-use sectors was unchanged from 2011 at: 38% for metallurgical uses, 31% for environmental uses, 22% for chemical and industrial uses, 8% for construction uses, and 1% for refractory dolomite (table 3). These end-use data were based on lime sold and used by domestic producers and do not include lime imports.

U.S. commercial sales accounted for 92% of total lime consumption and 93% of domestic production. Captive lime accounted for the remainder of consumption and was used in the production of steel in basic oxygen furnaces (BOF), magnesia production, precipitated calcium carbonate production, sugar refining, and refractories (dead-burned dolomite). Almost all end-use data on captive lime consumption are withheld to avoid disclosing company proprietary information. As a result, table 3 only lists the total quantity (commercial plus captive) by end use. End uses with captive consumption are listed in footnote 5 of the table.

In steel refining, quicklime is used as a flux to remove impurities, such as phosphorus, silica, and sulfur. The steel industry accounted for about 30% of lime sold and used by domestic lime producers. The U.S. steel industry's recovery from the effects of the 2008–09 recession slowed in 2012 with raw steel production increasing by less than 3% to 88.6 Mt (World Steel Association, undated). Lime consumption for steelmaking in 2012, however, actually decreased slightly (by less than 2%) in comparison with that of 2011.

In nonferrous metallurgy, lime is used in the beneficiation of copper ores to neutralize the acidic effects of pyrite and other iron sulfides and to maintain the proper pH in the flotation process. Lime is used to process alumina and magnesia, to extract uranium from gold slimes, to recover nickel by precipitation, and to control the pH of the sodium cyanide solution used to leach gold and silver from the ore.

Gold and silver are recovered using heap leaching and by conventional milling and subsequent leaching of the slurry. The sodium cyanide solution dissolves gold from the ore and forms a stable gold-cyanide complex, and the gold can then be separated through the use of highly activated carbon. Heap leaching involves crushing the ore, mixing it with lime for pH control and agglomeration, and stacking the ore in heaps on specially prepared pads for treatment with cyanide solution. Lime is used to maintain the pH of the cyanide solution at a level between 10 and 11 to maximize the recovery of precious metals and to prevent the creation of hydrogen cyanide.

Lime consumption data for these various nonferrous metallurgy uses (aluminum and bauxite processing, concentration of copper and gold ores, and unspecified nonferrous uses) are combined to avoid disclosing company proprietary data and are reported in table 3 under metallurgical, nonferrous metallurgy. In 2012, lime consumption in nonferrous metallurgy increased slightly to 1.35 Mt, nearly reaching its peak of 1.37 Mt reached in 2007 and 2008. Although specific data are not collected on lime consumption for copper recovery or for gold recovery, they make up a large part of the nonferrous metallurgy market. In 2012, as a result of mine production increases in Arizona, Nevada, and New Mexico, production of copper flotation concentrates increased by more than 4% compared with that of 2011 (Edelstein, 2013). U.S. gold production, however, decreased by 3% compared with that of 2011 (George, 2013).

Lime is used in numerous processes designed to treat mining-related pollutants in active or abandoned mines. These processes include the treatment of acid-mine drainage from operating and abandoned mines, specialized treatment processes such as catalyzed cementation of arsenic and other heavy metals, and the treatment of mine tailings that result from the recovery of precious metals to recover cyanides.

Lime is used, generally in conjunction with soda ash, for softening municipal and plant process water. This precipitation process removes bivalent soluble calcium and magnesium cations (and to a lesser extent, ferrous iron, manganese, strontium, and zinc) that contribute to the hardness of water. This process also reduces carbonate alkalinity and total dissolved solids. Lime consumption for drinking water treatment was essentially unchanged compared with that of 2011.

In sewage treatment, the traditional role of lime is to control pH in the sludge digester, where it removes dissolved and suspended solids that contain phosphates and nitrogen compounds. Lime also aids in clarification and in destroying harmful bacteria. The leading modern use in sewage treatment is to stabilize the resulting sewage sludge. Sewage sludge stabilization, also called biosolids stabilization, reduces odors, pathogens, and putrescibility of the solids. Lime stabilization involves mixing quicklime with the sludge to raise the temperature and pH of the sludge to minimum levels for a specified period of time. In 2012, lime consumption for all sludge treatment increased by nearly 10% compared with that of 2011. All of the consumption increase was in the treatment of industrial wastes as treatment of sewage sludge was unchanged.

In flue gas desulfurization (FGD) systems serving coal-fired powerplants, incinerators (most are waste-to-energy powerplants), and industrial plants, lime is injected into the flue gas to remove gaseous pollutants, particularly sulfur dioxide (SO_2) and hydrochloric acid (HCl). Many FGD systems at utility powerplants are now designed to produce byproduct gypsum from the captured SO_2. This byproduct material is suitable for use in manufacturing gypsum wallboard, as an additive in portland cement, and as a soil amendment in agriculture. Hydrated lime may be used in another FGD-related market—to control sulfur trioxide (SO_3) emissions from selective catalytic reduction (SCR) systems installed at powerplants to control emissions of nitrogen oxides (NO_x). Utility powerplants were by far the largest consumers of lime for FGD and accounted for 91% of the total FGD lime market in 2012. Incinerators, industrial boilers, and other FGD uses accounted for the remaining 9%. In 2012, lime consumption in all FGD markets decreased by about 4% compared with that of 2011. The utility powerplants sector decreased by 168,000 t, while the incinerators and industrial boilers increased 10,000 t and 18,000 t, respectively. The use of hydrated lime in FGD treatment in 2012 increased to 265,000 t, a 12% increase compared with the revised figure for 2011. Much of this increase

is attributed to the treatment of SO_3 emissions from SCR systems at utility powerplants.

Lime is used by the pulp and paper industry in the basic Kraft pulping process where wood chips and an aqueous solution (called liquor) of sodium hydroxide and sodium sulfide are heated in a digester. The cooked wood chips (pulp) are discharged under pressure along with the spent liquor. The pulp is screened, washed, and sent directly either to the paper machine or to the bleaching plant. Lime is sometimes used to produce calcium hypochlorite bleach for bleaching the paper pulp. The spent liquor is processed through a recovery furnace, where dissolved organics are burned to recover waste heat, sodium sulfide, and sodium carbonate. The recovered sodium sulfide and sodium carbonate are diluted with water and then treated with slaked lime to recausticize the sodium carbonate into sodium hydroxide (caustic soda) for reuse. The byproduct calcium carbonate is recalcined in a lime kiln to recover lime for reuse. The paper industry also uses lime as a coagulant aid in the clarification of plant process water. In 2012, consumption for pulp and paper production decreased by about 3% compared with that of 2011.

Lime is used to make precipitated calcium carbonate (PCC), a specialty filler used in premium-quality coated and uncoated papers, paint, and plastics. The most common PCC production process used in the United States is the carbonation process. Carbon dioxide is bubbled through milk-of-lime to form a precipitate of calcium carbonate and water. The reaction conditions determine the size and shape of the resulting PCC crystals. Lime used for PCC production decreased by 5% compared with that of 2011.

The chemical industry uses lime in the manufacture of alkalis. Quicklime is combined with coke to produce calcium carbide, which is used to make acetylene and calcium cyanide. Lime is used to make calcium hypochlorite, citric acid, petrochemicals, and other chemicals.

In sugar refining, milk-of-lime is used to raise the pH of the product stream, precipitating colloidal impurities. The lime itself is then removed by reaction with CO_2 to precipitate calcium carbonate.

In road paving, hydrated lime is used in hot mix asphalt to act as an antistripping agent. Stripping is generally defined as a loss of adhesion between the aggregate surface and the asphalt cement binder in the presence of moisture. Lime also is used in cold, in-place recycling for the rehabilitation of distressed asphalt pavements. Existing asphalt pavement is pulverized using a milling machine, and a hot lime slurry is added along with asphalt emulsion. The cold recycled mix is placed and compacted by conventional paving equipment, which produces a smooth base course for the new asphalt surface. In 2012, sales of lime for use in asphalt decreased by about 11% compared with those for 2011.

Hydrated lime and quicklime also are used to stabilize fine-grained soils in place of materials that are employed as subbases, such as hydraulic clay fills or otherwise poor-quality clay and silty materials obtained from cuts or borrow pits. Lime also is used in base stabilization, which includes upgrading the strength and consistency properties of aggregates that may be judged unusable or marginal without stabilization. Common applications for lime stabilization included the construction of airfields, building foundations, earthen dams, parking areas, and roads.

Lime sales for soil stabilization tend to be cyclical, especially in large market areas such as Texas. In the soil stabilization market, lime competes with portland cement, cement kiln dust, fly ash, and other additives (liquid enzymes, for example). Choices made by consumers can depend on availability, price, contract specifications, soil chemistry, and State and Federal funding in the case of highway construction projects. In 2012, the soil stabilization market continued to be adversely affected by the slow recovery from the recession and by reduced highway spending at the State level. Lime consumed for soil stabilization in 2012 was essentially unchanged compared with that of 2011.

Hydrated lime is used in the traditional building sector in mortars, plaster, and stucco. Standard masonry cement mortars that include lime exhibit superior workability balanced with appropriate compressive strength, as well as low water permeability and superior bond strength. Lime is a major constituent in exterior and interior plasters and stuccos, enhancing the durability, strength, and workability of these finishes. A small amount of hydrated lime also is used in the renovation of old structures built with lime mortars, which were standard before the development of portland cement mortars. Modern portland cement-base mortars are incompatible with old lime mortars. Hydrated lime also is used to make synthetic hydraulic lime, which is produced by blending powdered hydrated lime with pulverized pozzolanic or hydraulic materials.

The U.S. Census Bureau collects data on construction spending for residential construction and 16 categories of nonresidential construction. As a sign that the U.S. construction industry is beginning to recover from the 2008–09 recession, the value of private construction increased by 17% and the value of residential housing increased by 15% compared with that of 2011. In comparison, the value of public construction decreased by about 3% (U.S. Census Bureau, 2013). Almost all lime sold for traditional building uses in 2012 was in the form of hydrate (225,000 t of hydrate out of 226,000 t of total lime in 2012). In 2012, sales of lime for traditional building uses increased by 7% compared with those of 2011. Most of the lime sold for building uses was produced at a few plants in Nevada, Ohio, Texas, and Wisconsin.

A new agricultural use for hydrated lime that has been undergoing experiments and field trials is as an additive to crop residues, such as corn stover, to produce cattle feed that can replace a substantial portion of the grain normally fed to cattle. The crop residue is ground, treated with hydrated lime slurry, and then stored in an oxygen-free container—typically a plastic "ag bag" or a bunker—for at least a week. The hydrated lime makes the crop residue digestible by the cattle. This treated crop residue can replace about 20% of grain fed to the cattle, and with the addition of wet distiller grains (a byproduct of corn ethanol production), provide protein to the treated crop residue that could conceivably replace more than 60% of the grain (Archer Daniels Midland Co., 2013). The extent of lime use in this sector is unknown; the USGS currently does not collect data on this market.

Hydrated lime is used in oil and gas drilling where it is used as a source of alkalinity and calcium in both oil- and water-base drilling fluids. Drilling fluid applications include increasing pH, providing excess lime as an alkalinity buffer, flocculating bentonite drilling muds, removing soluble carbonate (CO_3^{-2}) ions, controlling corrosion, and activating fatty-acid oil-base mud additives (M-I LLC, 2011).

Dead-burned dolomite, also called refractory lime, is used as a component in tar-bonded refractory brick or monolithics manufactured for use in BOF. Refractory brick also is used in the lining of many treatment and casting ladles, in argon-oxygen decarburization and vacuum-oxygen decarburization converters, in electric arc furnaces (EAF), and in continuous steel casting. The data reported in this chapter were rounded to one significant figure to avoid disclosing company proprietary data: unrounded data showed that the production of dead-burned dolomite in 2012 decreased compared with that of 2011. Magnesita Refractories Co. (formerly LWB Refractories Co.) at its York, PA, plant and Carmeuse at its Millersville, OH, plant were the only significant dead-burned dolomite producers. Although dead-burned dolomite is the primary form of lime used in refractories, hydrated lime may be used to produce silica refractory brick used to line industrial furnaces.

Prices

All value data for lime are reported by type of lime produced—high-calcium quicklime, high-calcium hydrate, dolomitic quicklime, and dolomitic hydrate. To avoid revealing company proprietary data, value data for dead-burned dolomite were included with the averages for all types. Prices for all types of lime increased compared with those for 2011. The average values listed in table 5 are free-on-board plant basis including the cost of containers.

Foreign Trade

The United States exported and imported calcined dolomite (dolomitic lime), hydrated lime (slaked lime), hydraulic lime, and quicklime. Combined exports of lime were 212,000 t valued at $36.7 million. About 90% of exports went to Canada, with most of the remaining exports going to Mexico (3%) and Oman (2%) (table 6).

Combined imports of lime were 468,000 t valued at $68.3 million, with more than 95% from Canada, 4% from Mexico, and 1% from other countries (table 7). Canada provided almost all imports of high-calcium (99%) and dolomitic quicklime (98%). Imports of hydrated lime came mostly from Canada (69%) and Mexico (29%).

No tariffs are placed on imports of hydraulic lime, quicklime, and slaked lime from countries with normal trade relations (NTR) with the United States. A 3% ad valorem tariff is placed on imports of calcined dolomite from NTR countries.

World Review

Lime is not a commodity that is traded widely internationally. Traditionally, lime has been a low-value bulk product that could not be shipped long distances and compete with lime produced locally. Most countries have limestone or dolomite deposits and, as a result, are able to manufacture lime for their own consumption. There may be some trade between countries on a regional basis where distances are not too great, such as in the European Union, or to supply lime products of a quality not locally available.

With the exception of some industrialized nations, accurate lime production data for individual countries are difficult to obtain. Besides production by large commercial lime companies, lime is produced by small-scale manufacturers operating simple kilns to supply individual villages and by industries producing lime for internal consumption. These variations and the frequent confusion with limestone data make accurate collection of international lime data difficult and certainly incomplete. In some cases, lime sales data have been used to estimate country production figures. Beginning in 2006, major revisions were made to the annual estimates for China based on new information. Beginning in 2009, major revisions were made to annual estimates for India, based on steel production and other market assumptions (table 8).

Outlook

Economic forecasts predict sustained economic growth as indicated by the strengthening of the labor market, strong equity market values, and signs of recovery in the housing market. The U.S. economy is expected to grow in 2013, albeit at a rather weak pace compared with historical rates. Growth is expected to accelerate in 2014. The consensus forecasts are for growth in the U.S. real gross domestic product of 1.9% for 2013 and 2.9% for 2014. Growth is expected to be restrained in 2013 by multiple factors, including the expiration of the Social Security payroll tax holiday at the end of 2012 and tightening Federal fiscal policy (New York Consensus Forecasting Conference, 2013). Lime sales in markets such as chemical and industrial, construction, and steel is expected to increase with improvements in the overall economy.

The outlook for FGD (lime's second leading market) is more difficult to analyze. With the recent boom in natural gas exploration, large increases in natural gas reserves, and lower natural gas prices, some U.S. electric utilities have shifted their fuel use from coal to natural gas. Natural gas also has the advantage of emitting fewer pollutants than coal and, as a result, makes it easier for the power industry to acquire the necessary air pollution permits to construct new powerplants or expand existing ones. Natural-gas-fired powerplants do not require SO_2 scrubbing, so there would be a potential decrease in FGD lime consumption as a result.

Wet limestone scrubbing (WLS) has been the preferred SO_2 removal technology for coal-fire powerplants in recent decades, but two potential issues have arisen. With the possible regulation of GHG emission in the future, the use of WLS becomes problematic because the process generates CO_2 as a byproduct. Second, WLS requires some form of purge stream to prevent accumulation of chlorides, high concentrations of dissolved sulfate, and often trace impurities of mercury and oxides of arsenic, boron, and selenium. Treatment methods have been and continue to be developed to remove these contaminants, but regulations are tightening with regard to disposal of powerplant wastewater streams. Two emerging technologies, novel integrated

desulfurization and circulating fluidized bed scrubbing (also called circulating dry scrubbing), combine features of previous technologies into a combined process that offers excellent SO_2 removal with efficient reagent use. Hydrated lime is the primary reactant in both systems (Buecker, 2011). As a result, the FGD market is expected to increase during the next 3 to 5 years despite the negative impact of fuel switching.

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TABLE 1
SALIENT LIME STATISTICS[1]

		2008	2009	2010	2011	2012
United States[2]						
Number of plants[3]		90	81	85	87	87
Lime sold or used by producers:						
Quantity	thousand metric tons	19,900	15,800	18,300	19,100	18,800
Value[4]	thousand dollars	1,840,000	1,660,000	1,950,000	2,130,000	2,230,000
Average value	dollars per metric ton	92.40	105.00	107.00	111.50	118.50
Quicklime:						
High-calcium	thousand metric tons	14,600	11,800	13,300	13,900	13,600
Dolomitic	do.	2,630	1,830	2,570	2,690	2,710
Total	do.	17,200	13,600	15,900	16,600	16,300
Hydrated lime:						
High-calcium	do.	2,070	1,690	1,910	2,010	2,020
Dolomitic	do.	358	261	239	230	237
Total	do.	2,420	1,950	2,150	2,240	2,260
Dead-burned dolomite[5]	do.	200	200	200	200	200
Lime sold by producers:						
Quicklime[6]	thousand metric tons	16,000	12,600	14,700	15,400	15,200
Hydrated lime	do.	2,420	1,950	2,140	2,240	2,250
Total	do.	18,400	14,500	16,900	17,700	17,500
Value[4]	thousand dollars	1,690,000	1,510,000	1,790,000	1,950,000	2,050,000
Lime used by producers	thousand metric tons	1,470	1,260	1,380	1,430	1,340
Value[4]	thousand dollars	149,000	150,000	169,000	183,000	177,000
Exports:[7]						
Quantity	thousand metric tons	174	108	215	231	212
Value[8]	thousand dollars	27,100	18,500	36,200	40,100	36,700
Imports for consumption:[7]						
Quantity	thousand metric tons	307	422	445	512	468
Value[9]	thousand dollars	39,400	53,200	61,500	69,900	68,300
Consumption, apparent[10]	thousand metric tons	20,000	16,100	18,500	19,400	19,100
World, production	do.	306,000 [r]	295,000 [r]	313,000	328,000 [r]	348,000 [e]

[e]Estimated. [r]Revised. do. Ditto.
[1]Data are rounded to no more than three significant digits; may not add to totals shown. Excludes regenerated lime.
[2]Includes Puerto Rico.
[3]Includes most producer-owned hydrating plants not located at lime plants.
[4]Selling value, free on board plant.
[5]Data are rounded to no more than one significant digit to avoid disclosing company proprietary data.
[6]Includes dead-burned dolomite.
[7]Source: U.S. Census Bureau.
[8]Declared free alongside ship valuation.
[9]Declared cost, insurance, and freight valuation.
[10]Defined as sold or used plus imports minus exports.

TABLE 2
LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY U.S. CENSUS BUREAU REGIONS

Region or division	Hydrated (thousand metric tons)	Quicklime[1] (thousand metric tons)	Total (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total
2011:						
Northeast[2]	178	1,070	1,250	7	$170,000	8
Midwest[3]	732	6,830	7,560	40	827,000	39
South:						
South Atlantic[4]	205	602	807	4	103,000	5
East South Central[5]	204	4,540	4,740	25	487,000	23
West South Central[6]	673	1,140	1,810	9	195,000	9
West[7]	250	2,690	2,940	15	347,000	16
Total	2,240	16,900	19,100	100	2,130,000	100
2012:						
Northeast[2]	162	1,010	1,170	6	165,000	7
Midwest[3]	761	6,570	7,330	39	859,000	39
South:						
South Atlantic[4]	210	607	817	4	110,000	5
East South Central[5]	222	4,430	4,660	25	517,000	23
West South Central[6]	665	1,150	1,810	10	201,000	9
West[7]	236	2,790	3,030	16	378,000	17
Total	2,260	16,600	18,800	100	2,230,000	100

[1]Includes dead-burned dolomite.
[2]Region includes lime sold and used in the States of Massachusetts and Pennsylvania.
[3]Region includes lime sold and used in the States of Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.
[4]Division includes lime sold and used in the States of Florida, Georgia, Puerto Rico, Virginia, and West Virginia.
[5]Division includes lime sold and used in the States of Alabama, Kentucky, and Tennessee.
[6]Division includes lime sold and used in the States of Arkansas, Louisiana, Oklahoma, and Texas.
[7]Region includes lime sold and used in the States of Arizona, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming.

TABLE 3
LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1, 2, 3]

(Thousand metric tons)

Use	2011 Quantity[4]	2012 Quantity[4]
Chemical and industrial:		
Fertilizer, including aglime	45	84
Glass	167	168
Paper and pulp	921 r	890
Precipitated calcium carbonate	929 r	880
Sugar refining	686	651
Other chemical and industrial[5]	1,460	1,480
Total	4,200	4,150
Metallurgical:		
Steel and iron:		
Basic oxygen furnaces	2,560	2,450
Electric arc furnaces	3,010	3,050
Other steel and iron	263	227
Total	5,840	5,730
Nonferrous metallurgy[6]	1,330	1,350
Total metallurgical	7,170	7,080
Construction:		
Asphalt	265	237
Building uses	211	226
Soil stabilization	1,010	1,010
Other construction	52	56
Total	1,540	1,530
Environmental:		
Flue gas desulfurization (FGD):		
Utility powerplants	3,650	3,490
Incinerators	212	222
Industrial boilers and other FGD	85 r	103
Total	3,950	3,810
Sludge treatment:		
Sewage	104	104
Other, industrial and hazardous	122	144
Total	227	249
Water treatment:		
Acid-mine drainage	120	84
Drinking water	913	920
Wastewater	530	555
Total	1,560	1,560
Other environmental	224	217
Total environmental	5,970	5,830
Refractories (dead-burned dolomite)	200 [7]	200 [7]
Grand total	19,100	18,800

[r]Revised.

[1]Includes Puerto Rico.

[2]Data are rounded to no more than three significant digits; may not add to totals shown. Excludes regenerated lime.

[3]The U.S. Geological Survey does not collect value data by end use; in previous years value data were estimated.

[4]Quantity includes lime sold and used, where "used" denotes lime produced for internal company use for basic oxygen furnaces, magnesia, paper and pulp, precipitated calcium carbonate, refractories, and sugar refining.

[5]May include alkalis, calcium carbide and cyanamide, calcium hypochlorite, citric acid, food (animal or human), oil and grease, oil well drilling, petrochemicals, tanning, and other uses. Magnesia is included here to avoid disclosing proprietary data.

[6]Includes aluminum and bauxite, magnesium, ore concentration (copper and gold), and other nonferrous uses.

[7]Data are rounded to no more than one significant digit to avoid disclosing company proprietary data.

TABLE 4
HYDRATED LIME SOLD OR USED IN THE UNITED STATES, BY END USE[1, 2, 3]

(Thousand metric tons)

Use	2011 Quantity[4]	2012 Quantity[4]
Chemical and industrial	582	591
Construction:		
Asphalt	236	217
Building uses	200	225
Soil stabilization	423	415
Other construction	14	8
Total	874	866
Environmental:		
Flue gas desulfurization (FGD):		
Utility powerplants	173	188
Incinerators	31	32
Industrial boilers and other FGD	31	45
Total	236 r	265
Sludge treatment:		
Sewage	19	20
Other sludge treatment	30	50
Total	49	71
Water treatment:		
Acid-mine drainage	68	32
Drinking water	149	152
Wastewater	179	194
Total	396	379
Other environmental	64	44
Metallurgy	41	41
Grand total	2,240	2,260

[r]Revised.
[1]Includes Puerto Rico.
[2]Data are rounded to no more than three significant digits; may not add to totals shown. Excludes regenerated lime.
[3]The U.S. Geological Survey does not collect value data by end use; in previous years value data were estimated.
[4]Quantity includes hydrated lime sold and used, where "used" denotes lime produced for internal company use in building, chemical and industrial, and metallurgical sectors.

TABLE 5
LIME PRICES[1]

Type	2011		2012	
	Dollars per metric ton	Dollars per short ton[2]	Dollars per metric ton	Dollars per short ton[2]
Sold and used:				
Quicklime	107.90	97.90	115.40	104.70
Hydrate	130.90	118.70	136.90	124.20
Average all types[3]	111.50	101.10	118.50	107.50
Sold:				
High-calcium quicklime	104.70	95.00	112.20	101.80
Dolomitic quicklime	117.80	106.80	124.20	112.70
Average quicklime	106.80	96.90	114.20	103.60
High-calcium hydrate	129.80	117.80	134.90	122.40
Dolomitic hydrate	142.20	129.00	157.40	142.70
Average hydrate	131.10	118.90	137.30	124.50
Average all types[3]	110.10	99.90	117.50	106.60

[1]Average value per ton, free-on-board plant, including cost of containers.
[2]Unit values in metric and short tons were rounded independently.
[3]Includes dead-burned dolomite.

TABLE 6
U.S. EXPORTS OF LIME, BY TYPE[1]

(Metric tons and dollars)

Type and country	2011		2012	
	Quantity	Value[2]	Quantity	Value[2]
Calcined dolomite:				
Argentina	--	--	60	13,300
Brazil	--	--	3,750	869,000
Canada	51,400	9,530,000	52,200	9,520,000
Colombia	57	50,900	131	53,100
France	1,060	235,000	500	143,000
Germany	3,140	649,000	280	79,800
Japan	118	187,000	97	140,000
Mexico	216	52,300	259	86,100
Taiwan	--	--	80	27,400
Other	74 r	67,200 r	116	76,500
Total	56,100	10,800,000	57,500	11,000,000
Hydraulic lime:				
Bahamas, The	141	26,600	100	21,800
Canada	7,340	1,860,000	6,410	1,450,000
Vietnam	161	29,000	--	--
Other	178	124,000	233	167,000
Total	7,820	2,030,000	6,750	1,640,000
Quicklime:				
Argentina	43	34,500	--	--
Bahamas, The	77	19,400	164	38,900
Canada	121,000	16,800,000	114,000	16,900,000
Costa Rica	136	42,600	533	218,000
Mexico	8,870	976,000	6,490	810,000
Netherlands	64	85,100	67	98,000
Russia	15,300	4,590,000	568	687,000
Suriname	1,800	610,000	--	--
United Arab Emirates	69	64,500	117	175,000
Other	85 r	120,000 r	268	186,000
Total	148,000	23,300,000	122,000	19,100,000
Slaked lime, hydrate:				
Angola	371	152,000	473	173,000
Canada	16,300	3,070,000	18,500	3,330,000
Nigeria	389	118,000	362	111,000
Oman	998	118,000	4,640	689,000
Trinidad and Tobago	632	182,000	191	56,600
Other	296 r	366,000 r	788	605,000
Total	19,000	4,000,000	24,900	4,970,000
Grand total	231,000	40,100,000	212,000	36,700,000

rRevised -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Declared free alongside ship valuation.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF LIME, BY TYPE[1]

(Metric tons and dollars)

Type and country	2011		2012	
	Quantity	Value[2]	Quantity	Value[2]
Calcined dolomite:				
Canada	67,900	10,500,000	51,600	8,350,000
Italy	139	113,000	818	169,000
Mexico	1	5,330	203	34,400
Other	64 r	71,100 r	14	62,100
Total	68,100	10,700,000	52,600	8,620,000
Hydraulic lime:				
Canada	104	13,800	91	10,500
France	71	39,000	224	166,000
Other	--	--	99	39,200
Total	175	52,900	414	215,000
Quicklime:				
Canada	386,000	49,400,000	359,000	48,500,000
Dominican Republic	469	159,000	484	196,000
Mexico	2,040	390,000	2,870	498,000
Other	275 r	314,000 r	432	381,000
Total	388,000	50,300,000	363,000	49,500,000
Slaked lime, hydrate:				
Belgium	541	268,000	385	241,000
Canada	29,500	3,930,000	35,500	6,100,000
Dominican Republic	489	173,000	132	48,400
Mexico	24,200	4,030,000	14,700	2,700,000
Netherlands	--	--	481	249,000
Other	983 r	774,000 r	681	815,000
Total	55,100	8,910,000	51,500	9,920,000
Grand total	512,000	69,900,000	468,000	68,300,000

rRevised -- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Declared cost, insurance, and freight valuation.

Source: U.S. Census Bureau.

TABLE 8

QUICKLIME AND HYDRATED LIME, INCLUDING DEAD-BURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2008	2009	2010	2011	2012[e]
Australia, sales[e]	2,200	2,500 [r]	2,200 [r]	2,200 [r]	2,200
Austria	909 [r]	725 [r]	774 [r]	780 [r, e]	780
Belgium[e]	2,400 [r]	2,400 [r]	2,400 [r]	2,400 [r]	2,400
Bosnia and Herzegovina	216	281	339	489 [r]	490
Brazil	7,425 [r]	6,600 [r]	7,761 [r]	8,235 [r]	8,300
Bulgaria	1,422	950	1,309	1,495 [r]	1,500
Canada	2,069	1,601	1,913	1,959	1,955 [p, 4]
Chile[e]	820	790	790	760 [r]	750
China[e]	180,000	185,000	190,000	200,000	220,000
Croatia	541	350 [r]	330 [r]	271 [r]	425
Czech Republic[e]	1,150 [4]	1,000	1,000 [r]	1,000	1,000
Egypt[e]	1,000 [4]	800	800	800	800
Finland[e]	482 [4]	500	475	475	475
France[e]	4,000	3,500	3,800	3,900	3,900
Germany	7,313	5,945	6,856	7,113 [r]	6,672 [4]
Hungary[e]	250 [r]	210 [r, 4]	260 [r, 4]	250 [r]	250
India[e]	13,000	13,000	14,000	15,000	15,000
Iran[e]	2,700	2,600	2,700	2,800	2,800
Ireland[e]	240	220	220	300	300
Israel	481	429	658	715 [r]	720
Italy[e, 5]	5,900	5,400	6,000	6,200	6,200
Jamaica[e]	313 [4]	300	300	300	300
Japan, quicklime only	9,528	6,746	8,547	8,005 [r]	8,200
Kazakhstan	906	798	881	958	886 [4]
Korea, Republic of [e]	4,000	3,700 [r]	4,400 [r]	5,100 [r]	5,200
Malaysia, sales[e]	900	1,000 [r]	1,000 [r]	1,000	1,100
Peru[e]	216	216	216	216	220
Poland	1,952	1,704 [r]	1,799	2,036 [r]	2,000
Romania[e]	2,000	1,600	2,000	2,000	2,000
Russia[e]	8,200	7,000	9,500 [r, 4]	10,100 [r, 4]	10,500
Serbia	292	251	239	274 [r]	270
Slovakia	1,082	867	986 [r]	971 [r]	1,000
Slovenia[e]	1,500	1,500	1,500	1,200	1,200
South Africa, burnt lime sales	1,577 [r]	1,368 [r]	1,292 [r]	1,539 [r]	1,500
Spain, sales[e]	2,000	1,800 [r]	1,900 [r]	1,900 [r]	1,800
Sweden[e]	750	600	700	700	700
Taiwan[e]	450	450	460 [r]	460 [r]	460
Thailand, sales[e]	770	770	800	800	800
Tunisia	369	366	348 [r]	283 [r]	300
Turkey[e, 6]	4,000	3,800	4,300	4,300 [r]	4,500
Ukraine	5,128	4,101	4,220	4,253	4,196 [4]
United Kingdom[e]	1,500	1,500	1,500	1,500	1,500
United States, including Puerto Rico	19,900	15,800	18,300	19,100	18,800 [4]
Venezuela[e]	400	400	400	400	400
Vietnam	1,619	1,584	1,454	1,600 [r]	1,500
Other[e]	1,850 [r]	1,700 [r]	1,720 [r]	1,570 [r]	1,630
Total	306,000 [r]	295,000 [r]	313,000	328,000 [r]	348,000

[e]Estimated. [p]Preliminary. [r]Revised.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through June 12, 2013.

[3]In addition to the countries listed, Argentina, Chad, Iraq, Lebanon, Mexico, Nigeria, Pakistan, Saudi Arabia, Syria, Thailand, and several other nations produce lime, but output data are not reported; available general information is inadequate to formulate reliable estimates of output levels.

[4]Reported figure.

[5]Includes hydraulic lime.

[6]Production estimate based on sales only; data may be incomplete.