INDUSTRIAL STRATEGIES FOR IMPROVING ENERGY EFFICIENCY AND REDUCING GREENHOUSE GAS EMISSIONS: EXAMPLES FROM THE CLIMATE WISE PROGRAM

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THE CLIMATE WISE PROGRAM

Climate Wise is a partnership initiative between the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), and industry designed to stimulate the voluntary reduction of greenhouse gas emissions among participating manufacturing companies. Climate Wise is a foundation program of the Clinton Administration's Climate Change Action Plan (CCAP) which seeks to reduce greenhouse gas emissions in the industrial, residential, commercial, agricultural, and transportation sectors through the formation of voluntary public/private sector partnerships. CCAP was developed to meet the commitments of the United Nations Framework Convention on Climate Change (FCCC) under which the 150 participating countries have established goals to reduce greenhouse gas emissions to 1990 levels by the year 2000.

Climate Wise works with the manufacturing sector, which comprises 25 to 30 percent of the total U.S. energy consumption, to promote the continued and increased implementation of energy efficiency and other pollution prevention measures. Since the program's inception in 1994, over 300 companies representing most manufacturing SIC groups (20-39) have joined the program. At present, Climate Wise Partners represent approximately 10 percent of the U.S. manufacturing energy use (excluding feedstock use). (In 1994, the total U.S. manufacturing energy use (non-feedstock) was 16.5 quadrillion Btu.[1])

The program facilitates and accelerates the innovation of its Partners' energy efficiency achievements by encouraging broad corporate goals, providing extensive technical assistance to identify cost-effective measures, and facilitating a medium for companies to exchange information on efficiency measures. Partners identify their corporate goals, energy efficiency commitments, and pollution prevention strategies in their Climate Wise "Action Plan."

To more effectively interface with industrial manufacturing companies and to target specific energy intensive sectors, Climate Wise is developing partnerships with key industry trade associations. Each partnership, termed "Climate Wise/Trade Association Compact," is tailored to suit the specific needs of each industrial sector. At present, Climate Wise has formed a compact with the American Portland Cement Alliance (APCA) (the principal cement trade association in the U.S.) and is currently working to form compacts with the American Iron and Steel Institute and the Steel Manufacturers Association. The APCA has found that by working in partnership with Climate Wise it can offer its members access to technical assistance, positive publicity, bench-marking opportunities, and financial savings through energy efficiency improvements.

As part of the program's focus on developing compacts, Climate Wise prepared industry profiles and developed sample Action Plans for several energy intensive industries. The sample Action Plans inform companies of the energy efficiency opportunities specific to their industry and the energy savings and CO_2 emission reductions for typical companies. Action Plans are vehicles for encouraging broad industry participation.

This paper reviews the energy use and CO_2 emissions profiles of the following three energy intensive industries: cement, petroleum, and iron and steel. The paper also identifies what a typical Action Plan for a company from each of these industries might look like and the types of savings (energy, CO_2 emissions, and energy costs) which might be achieved. The measures featured in these Action Plans are widely applicable and are likely to offer relatively short payback times. In addition, the paper describes other measures and existing or emerging technologies that may be available to these industries.

CLIMATE WISE ACTION PLAN

Prior to joining the program, potential Partners meet with Climate Wise representatives to discuss their emission reduction opportunities and goals. Six months after signing their "Partnership Agreement," Partners submit an Action Plan detailing their Climate Wise commitments. Typical industry energy efficiency commitments include equipment and manufacturing process efficiency improvements, fuel switching, and new product designs. After 18 months of program participation, Climate Wise Partners report their achievements under the Voluntary Reporting of Greenhouse Gases Emissions Program established under Section 1605(b) of the Energy Policy Act of 1992.

A well thought-out and comprehensive Action Plan provides a framework for planning and tracking energy efficiency improvements that are of significant benefit to the Partners. As a "living document," the plan can be adjusted to meet the changing needs of the Partner. The plan also enables Partners to evaluate their projects and make the necessary adjustments to ensure that the projects are contributing to the company's energy efficiency and pollution prevention goal.

A Partner's energy efficiency and pollution prevention goal is often expressed as a percentage reduction in energy use, energy use per unit of output, or as a specific greenhouse gas emissions reduction. Partners identify areas of potential efficiency improvements to meet this goal by conducting "walk-through" audits of their facilities, processes, and operations. Also, many Partners analyze their company's consumption and waste patterns of energy, water, and chemicals to determine areas which require improvement. After reviewing preliminary data (e.g., capital costs for new equipment, energy savings, net operating cost savings, emissions reductions, and other environmental benefits) on potential energy efficiency measures, Partners can develop a list of measures which best meet the company's goal.

Climate Wise offers several resources to assist Partners in developing their Action Plans. These include the following:

- Action Plan Software - assists Partners to identify promising actions and calculate their project-level energy savings and emission reductions.
- Climate Wise Case Study Compendium - highlights energy efficient and pollution prevention activities that Partners have successfully implemented.
- Opportunities Assessment Guide - assists Partners to identify energy saving and greenhouse gas emission reduction projects.
- Climate Wise *Wise Line* - provides general guidance to Partners concerning entity- or project-level energy saving and emission reduction calculations.

ENERGY EFFICIENCY AND THE CEMENT INDUSTRY

The hydraulic cement industry, SIC 3241, consists of those firms producing portland, masonry, prepared hydraulic, natural, lime, and oil well cements. Portland cement comprises 96 percent of the hydraulic cement production, with masonry cement comprising a significant proportion of the remaining four percent. The U.S. industry is recovering from a period of decreased profits which was largely attributed to the reduced demand for building materials and to competition from lower-cost cement imports.

Energy Use

The cement industry consumed 329 trillion Btu of energy for fuel in 1994, and represented 2 percent of the U.S. manufacturing industry's non-feedstock energy use.[2] The industry's energy use consists primarily of fossil fuel input to the clinker-producing kilns and electricity used to operate crushing and grinding equipment, material handling equipment, machinery drives, pumps, auxiliary equipment, fans, and pollution control equipment.

There are four primary methods of processing cement: wet kiln, dry kiln, preheater, and precalciner. The four methods use similar raw materials, but have different energy efficiencies due to the method of grinding raw meal or the configuration of the pre-processing step.[3] Cement production using a wet kiln is the most energy intensive method, consuming an average 6.5 million Btu per ton of cement produced.[4] During the wet kiln process, raw materials are ground with water to create a slurry which is approximately 30 to 40 percent water. The slurry is then fed into the kiln. This process is particularly energy intensive due to the amount of fuel that is required to separate the water from the mixture. No new wet kiln plants have been built since 1975.

Dry kilns require 11 percent less energy to produce a ton of cement as compared to wet kilns. During the dry kiln process, raw materials are ground dry and fed to the kiln. The energy efficiency of dry process kilns is often improved through the addition of preheater and precalciner systems which preheat and partially calcine the raw materials before they enter the kiln. The addition of preheater and precalciner systems reduce the energy consumption of the dry kiln by 20 and 23 percent, respectively.[5]

Energy Efficiency Improvements

Climate Wise has formed a partnership with the APCA to recruit cement companies. Eleven cement companies, representing almost 40 percent of the U.S. cement industry capacity, have joined the program. Other companies representing an additional 15 percent of the industry's capacity are expected to join Climate Wise in the near future. As a means to assist these new Partners in developing their goals and specific projects to achieve these goals, Climate Wise has prepared a sample Action Plan that identifies some energy efficiency measures for the industry:

- Inspect and repair leaks in compressed air system.
- Optimize heat transfer conditions in the clinker cooler.
- Install expert systems for kiln secondary control.
- Optimize raw mix components to achieve better burnability.
- Replace old kiln drive motors with high efficiency motors.

The above described measures could reduce energy consumption and CO_2 emissions at a cement facility producing 1 million tons of cement a year by approximately 8 percent and reduce energy costs by up to $700,000 per year. The most significant annual project-level energy savings and CO_2 emission reductions of up to 5 percent and energy cost savings of approximately $280,000 at this facility may result from optimizing heat transfer conditions in the clinker cooler through the improved distribution of clinker and air. The facility could achieve an estimated annual 2 percent energy savings and CO_2 emissions reduction and energy cost savings of over $100,000 by installing expert systems for kiln secondary control. Lastly, by optimizing the components of raw materials to obtain better burnability, energy use and CO_2 emissions may decrease by about 1 percent and energy costs could reduce by about $60,000 annually for this same facility. Climate Wise emphasizes that the above measures and related savings may not be representative for all cement facilities.

Climate Wise estimates that if measures similar to those described above are implemented by half of the cement facilities in the country, the industry's energy use and CO_2 emissions would decrease by approximately 3 to 4 percent.

Climate Wise has identified other energy efficiency measures that are being implemented in the industry. For example, by replacing the over-sized, flat, backward inclined blades on induced draft fans for pre-processing systems with lighter and stronger high efficiency airfoil fan impellers, a facility can save an estimated 3.6 GWh per year.[6] Listed below are a few efficiency measures which would likely be implemented by a new facility or by an existing facility during a major equipment upgrade:

- Install high efficiency classifiers in closed-circuit grinding plants (with savings of 3.0 - 7.5 kWh/ton);
- Reduce heat loss through kiln shell by improving refractories (with savings of 340,000 Btu/ton);
- Install low power blending silo (with savings of 1.4 kWh/ton).[7]

Through research under a cooperative effort with the Portland Cement Association, DOE's Office of Industrial Technologies (OIT) has developed the O-SEPA air separator to control the size distribution of cement particles while reducing grinding requirements. Conventional separators allow a large percentage of fine particles to be recirculated with coarser particles for regrinding. The O-SEPA unit separates the fine and coarse particles more effectively, thus reducing the quantity of particles that must be reground. Currently operating in 52 facilities in the U.S., the O-SEPA unit is estimated to reduce electricity requirements for grinding by about 20 percent and increase production by about 25 percent.[8]

ENERGY EFFICIENCY AND THE PETROLEUM INDUSTRY

The petroleum industry is classified as SIC 2911 which includes the production of petroleum products through the distillation and fractionalization of crude oil, redistillation of unfinished petroleum derivatives, cracking, or other processes. Petroleum refining is the physical, thermal, and chemical separation of crude oil into its major distillation fractions, which are then further processed through a series of separation and conversion steps into finished petroleum products. Along the way, contaminants such as sulfur and heavy metals are removed and beneficial compounds such as detergents are added. Petroleum products fall into three major categories:

- Fuels - gasoline, diesel, and distillate fuel oil, liquefied petroleum gas, jet fuel, residual fuel oil, kerosene, and coke (87.5% of U.S. refinery yield);
- Finished non-fuel products - solvents, lubricating oils, greases, petroleum wax, petroleum jelly, asphalt, and non-fuel coke (5.2% of U.S. refinery yield);
- Chemical industry feedstocks - naptha, ethane, propane, butane, ethylene, propylene, butylenes, butadiene, benzene, toluene, and xylene.[9]

Energy Use

The total energy (excluding feedstock use) consumed by the U.S. petroleum industry was 3.2 quadrillion Btu in 1994, representing 19 percent of the total manufacturing industry's energy use (non-feedstock).[10] The U.S. petroleum refining industry is the third largest industry in the world, accounting for about 21 percent of the world refining capacity.[11] The aggregate energy intensity in petroleum refining is affected by several interrelated factors such as refinery complexity, product mix, type of technology and process employed, and type of feedstock being processed. Modern, complex refineries tend to have much higher energy intensities than more simple distillation units. This is largely due to the additional energy requirements associated with the conversion and finishing process.

Energy Efficiency Improvements

In May 1997, British Petroleum Company p.l.c. (BP) joined Climate Wise with a strong commitment to action on climate change. BP is the sixth largest refinery in the U.S. (based on annual barrel production) and is the first of the top ten largest refineries to join Climate Wise.[12] Energy efficiency improvements have been a high priority for BP as the company improved the efficiency of its major manufacturing activities by approximately 20 percent during the last decade. Climate Wise is currently working with BP to develop a Climate Wise Action Plan. Through its parent company DuPont, Conoco, operating 5 pertroleum refineries and 20 natural gas processing plants, is a member of Climate Wise and is contributing to DuPont's goal of improving energy efficiency by 15 percent by the year 2000.[13]

Climate Wise is also working with Partner Total Petroleum Refinery (Total) in Denver, Colorado, recently acquired by Diamond Shamrock, Inc., on a program to demonstrate the energy efficiency of a waste-heat powered ammonia absorption refrigeration plant (WHAARP). Designed by Energy Concepts and built by Planetec, the 265 ton chiller plant acts as a debottlenecking device for the compressors by cooling the wet gas inlet vapors to 40°F, thus increasing the throughput of the fluid catalytic cracking process. The WHAARP technology could potentially recover nearly 65,000 barrels per year of liquefied petroleum gas (LPG) and 4.8 GWh of electricity.[14]

To assist our petroleum industry Partners, Climate Wise has identified eleven energy efficiency measures for a petroleum facility producing 36 million barrels per year. These measures are estimated to reduce the facility's annual energy consumption and CO_2 emissions by 10 percent and decrease fuel costs by about $8 million. The measures are listed below:

- Install air preheaters in the distillation process. (Air preheaters installed on heaters and boilers recover and transfer heat to the combustion air.)
- Improve fractionation in the distillation process. (High efficiency fractionation internals such as trays and packings enable the distillation tower to operate at lower flux rations, resulting in lower overall energy consumption.)
- Use hydraulic turbine recovery in both catalytic hydrocracking and hydrotreating. (During the hydraulic turbine recovery process, a high pressure separator liquid is fed to a low pressure separator liquid and dissolved gases are flushed from the liquid. The energy resulting from the pressure differential between the two liquids can be recovered and used to operate a pump in the hydrocracking or hydrotreating unit.)
- Improve catalysts in the alkylation process.
- Implement pinch technology for yield improvement. [Pinch technology is the process of analyzing the temperature characteristics of "cold streams" (streams that need to be heated) and "hot streams" to identify opportunities to minimize heating and cooling requirements and to recover heat.]
- Develop an energy management system to improve operating instrumentation and quality control. (Energy management systems include distributed control systems (DCS) and associated computer controls to optimize heater and boiler firing rates, control the oxygen content in the heater and boiler stacks to minimize fuel fired, and control the refinery steam system to minimize steam consumption.)
- Install mechanical vacuum pumps.
- Install a two-stage condenser.
- Install high efficiency transformers.
- Replace old motors with new high efficiency motors.
- Install high efficiency variable speed drives.

The most significant potential annual energy savings and CO_2 emissions reductions of about 3 percent and energy costs savings of approximately $2.2 million are from the installation of preheaters in the distillation process at this facility. By improving the fractionation in the distillation process, this facility's energy use and CO_2 emissions may decrease by an estimated 1 percent and energy costs may decrease by about $600,000 each year. Lastly, the installation of a turbine recovery train at the fluid catalytic cracker could reduce the facility's annual energy use and CO_2 emissions by approximately 1 percent and reduce energy costs by about $800,000. It is important to note that these measures may not be the best means for improving energy efficiency at all refineries.

Measures such as these, if implemented by half the petroleum refineries in the U.S., could decrease the industry's annual energy use and CO_2 emissions by 2 to 4 percent.

Significant improvements in refining technologies and processes have increased the energy efficiency of the three primary refining processes: distillation, cracking, and reforming. During the distillation process, crude oil is separated into distillate products (e.g., light gases, gasoline, LPGs, fuel oils, and residual oils). To reduce thermal losses during this process, refineries are working to better integrate heat use between the distillation units (primarily the crude and vacuum distillation units). Several recent studies of process integration suggest potential energy savings between 10 and 19 percent, with payback periods of between 7 and 24 months.[15] Other technologies include split-wall distillation column and high temperature cogeneration which would allow the refinery to take advantage of waste heat to generate electricity.[16]

The reforming process changes the structure of hydrocarbon molecules to increase the octane level. Significant energy savings are attainable during this process through the development and application of an advanced condensation process that will reduce the demand for traditional reformed hydrocarbons and save energy.

Estimated energy savings of nearly 50 percent are attainable from the application of these advanced condensation processes.[17]

More advanced energy efficiency improvements include improved combustion processes, low-grade waste heat recovery, advanced heat exchangers, and improved process heaters and steam boilers.[18]

ENERGY EFFICIENCY AND THE IRON AND STEEL INDUSTRY

The iron and steel industry has become a classic example of a mature industry in which financial success is determined by a company's ability to continuously cut costs. In the 1970s the industry's competitive position was weakened due to increased foreign competition. In addition, public policies designed to protect the environment and provide energy security increased energy outlays by the industry. To regain competitiveness and cut costs, the industry undertook a major restructuring in the 1980s. The energy crisis of the 1970s, along with the availability of high-quality, low-cost scrap material, facilitated the emergence of a new type of domestic steel producer. These producers, known as minimills, utilize an energy efficient electric arc furnace (EAF) rather than the more energy intensive basic oxygen furnace (BOF) used by integrated mills. (Steel is also produced by specialty mills which primarily use EAFs.) The EAF process achieved greater productivity than integrated producers and drove out many imports. The U.S. regained its competitive position and became one of the lowest-cost steel producers in the developed world. In 1994, EAFs were used to produce about 40 percent of the total steel manufactured in the U.S.

Energy Use

The U.S. iron and steel industry consumed 1.8 quadrillion Btu of energy (excluding feedstock use) in 1994.[19] On a global level, the iron and steel industry is the largest industrial energy consuming subsector. Blast Furnaces and Steel Mills (SIC 3312) account for approximately 11 percent of US manufacturing non-feedstock energy use.[20] In the U.S., the average energy consumption by integrated mills is about 16.1 MMBtu per ton of raw steel and by minimills is about 7.3 MMBtu per ton of raw steel.[21] Due to the high level of competition and decreased demand, the industry is very oriented toward decreasing production costs to improve profitability. As a result, the industry continues to focus on the development and implementation of new technologies to increase productivity, reduce costs, and improve energy efficiency.

In the U.S., the BOF has completely replaced the capital and energy intensive open hearth furnace (OHF) in integrated steel mills. (The BOF requires 7 percent less energy than that of an OHF, depending on the molten iron-to-scrap ratio).[22] In 1995, BOFs produced approximately 60 percent of U.S. steel output. A BOF is charged with molten iron from a blast furnace and steel scrap. The iron and scrap are then refined together with alloy materials such as maganese and fluxes such as dolomite. Oxygen is blown into the furnace at high velocities to accelerate combustion and remove impurities. No external gases or fuels are needed because the reaction between oxygen and carbon is exothermic.

An EAF produces carbon and alloy steels from scrap metal, which is melted and refined using electricity. Because EAFs use scrap as a feedstock, the production of pig iron in the blast furnace is not required, eliminating approximately half of the energy requirements.

Energy Efficiency Improvements

Climate Wise is currently working to form a Climate Wise/Trade Association Compact with the two steel trade associations: the American Iron and Steel Institute (representing larger steel mills such as integrated mills) and the Steel Manufacturers Association (representing smaller steel mills such as minimills). Sample Action Plans were prepared for two steel producing facilities: one operating a BOF and the other operating an EAF.

Seven energy efficiency measures were evaluated in the sample Action Plan for a steel company operating a BOF and producing 2 million tons of steel each year. The measures, listed below, may reduce the facility's annual energy use and CO_2 emissions by an estimated 8 percent and decrease energy costs by approximately $6 million:

- Introduce pulverized coal injection (PCI) technology in the blast furnace. (The PCI technology replaces the use of coke in the blast furnace with cheaper and cleaner pulverized coal.)

- Install movable armor in blast furnace. (Fitted to the upper levels of the blast furnace walls, movable armor spreads raw materials across the furnace's stock column to increase the column's permeability, thus allowing for the enhanced upward flow of gases.)
- Optimize furnace controls.
- Recover BOF-gas for fuel use and electricity generation.
- Install up-to-date refactories in furnaces.
- Repair air leaks and optimize operations in compressed air system.
- Replace older motors with high-efficiency motors.

The measures to introduce PCI technology and to install movable armor in the blast furnace are likely to achieve the most significant annual energy savings, CO_2 emissions reduction, and energy cost savings at this facility. The PCI technology could reduce energy use and CO_2 emissions by over 2 percent and may reduce energy costs by an estimated $1.2 million annually at this facility. By installing movable armor in a blast furnace, Climate Wise estimated that this facility may reduce its energy use and CO_2 emissions by about 2 percent and reduce energy costs by about $1 million per year. Lastly, by optimizing furnace controls, such as optimizing the air/fuel ratio and heat transfer controls in the blast furnace, this facility could annually reduce its energy consumption and CO_2 emissions by about 1 percent and save over $300,000 in energy costs. It is important to note that not all of the mentioned measures and related savings are appropriate for all BOF facilities.

The following five energy efficiency measures were evaluated by Climate Wise for an EAF facility producing 1.6 million tons of steel a year:

- Install scrap pre-heaters in a twin shell arrangement in the EAF. (Scrap preheaters use the hot waste gases generated during the steelmaking process to preheat the "cold" steel scrap prior to melting in the furnace.)
- Install oxyfuel burners in the EAF shell for melting assistance. [Oxyfuel burners burn high purity oxygen with hydrocarbon fuels (e.g., natural gas, heavy oils from refineries fuels, or tars from coke plants within the steel works). High purity oxygen expedites the melting of steel scrap to liquid steel, thereby decreasing the heat cycle time which is required to produce a batch of steel.]
- Install up-to-date refactories.
- Repair leaks and optimize operations in compressed air system.
- Replace older motors with high efficiency motors.

Once completed, these measures may reduce this facility's electricity use and CO_2 emissions by about 5 percent and reduce electricity costs by approximately $4 million per year. The most significant electricity savings and CO_2 emissions reduction of approximately 3 percent and electricity cost savings of about $2.1 million per year may be achieved at this facility by installing oxyfuel burners in the EAF shell for melting assistance. The facility may achieve an annual electricity savings and CO_2 emissions reduction of 2 percent and electricity cost savings of $1.5 million by installing scrap pre-heaters in a twin shell arrangement in the EAF. Climate Wise emphasizes that the above measures and related savings may not be representative for all EAF facilities.

Measures such as these, if implemented by half of the BOF and EAF facilities across the country, could reduce the industry's energy consumption and related CO_2 emissions by about 2 to 4 percent per year.

Climate Wise identified other typical measures with high potential savings that a facility may implement. These include: dry coke quenching at coke plants, savings 0.4 to 0.8 MMBtu per ton (25 to 50 percent reduction in coke oven energy use); top gas power recovery at the blast furnace, saving 0.4 MMBtu per ton; and direct rolling in the hot rolling mill, saving 1.8 MMBtu per ton (77 percent of hot rolling mill energy use).[23] General energy efficiency measures for the industry include performing regular equipment maintenance checks, implementing thermal efficiency improvements in coke ovens and furnaces (e.g., optimizing heat transfer conditions), and waste heat recovery.

The steel industry continues to actively research and develop new technologies to increase productivity and energy efficiency. Climate Wise has identified new energy efficient technologies which due to significant costs and other factors are more likely to be implemented by a new facility or by one undergoing a major equipment change. These technologies are described in the following paragraphs.

The post-combustion lance technology for EAFs, developed by Praxair, Inc., injects the necessary amount of secondary oxygen (O_2) to combust the carbon monoxide (CO) prior to its stack release. The system consists of a water-cooled lance and controls to inject O_2 to combust CO in and above the furnace's foamy slag. The technology can reduce energy use by about 40 to 50 kWh per ton of steel and is currently used in three EAFs in the U.S.[24]

A thin-slab casting (compact strip) process, pioneered by Nucor in 1989, will allow minimills to compete in the markets for sheet and strip products (currently accounting for approximately 47 percent of the steel industry's total shipments), and increase energy efficiency. Thin slab casting is a process whereby molten steel is squeezed through a funnel-shaped mold down to a thickness of 1.5 to 2.0 inches and is then transferred to a four-stand finishing train designed to eliminate the need for reheating and several subsequent processing stages.[25] Before the advent of thin-slab casting, minimills could not enter this market due to the prohibitively high start-up costs. However, the new thin-slab casters cost considerably less than conventional casters, sharply reducing the capital expenditures required to enter the sheet and strip market. Nucor, the sole minimill to produce flat-rolled products using the thin-slab process, anticipates flat-rolled production to reach 4 million tons by mid-1996. Thin slab casting is expected to decrease energy consumption by 70 percent compared to conventional continuous casting and hot strip mills.[26]

The steel industry is actively pursuing alternatives to conventional coke-oven/blast furnace methods of steel production, such as direct steelmaking which eliminates the need for coke ovens. The DOE, in 1989, established an experimental direct steelmaking plant in Pittsburgh, run under the auspices of the American Iron and Steel Institute. In direct steelmaking, steel is produced using a coal-based, continuous in-bath melting process which substitutes a single vessel for coke ovens, blast furnaces, and BOFs. This process reduces the number of processes to one and requires about 20 percent less energy, resulting in potential U.S. energy savings of 200 trillion Btu per year.[27] Currently, the experimental plant is capable of producing five tons of molten steel per hour.

AK Steel has pioneered a new technique to increase the output of BOFs. The oxygen-blowing technique is one in which liquid oxygen is injected into the furnace to increase productivity and output. This technique enabled AK Steel to produce an output of 12 tons of hot metal per 100 cubic feet of working volume, while the national average is 6.5 tons of hot metal per 100 cubic feet of working volume.[28]

CLIMATE WISE OUTLOOK

The manufacturing industry's continued participation in the Climate Wise program and other Voluntary Programs, will substantially contribute to the Administration's goal of reducing greenhouse gas emissions to 1990 levels by the year 2000. The implementation of industry specific measures, such as those presented in this paper, by energy intensive industries will play an integral role in achieving the Administration's goal. Climate Wise looks forward to the continued formation of Climate Wise/Trade Association Compacts, similar to that formed with the American Portland Cement Alliance, as an effective means of recruiting energy intensive industries and informing them of industry specific energy efficiency opportunities.

In addition to Climate Wise's promotion of industry specific energy efficiency measures, the program also encourages its Partners to implement general efficiency improvements which include energy efficient lighting and motor upgrades, as these improvements can significantly contribute to the Partner's efficiency achievements. Although the voluntary nature of the Climate Wise program does not require its Partners to obtain a specific goal or to implement specific measures, most Partners have committed to progressive energy efficient and pollution prevention goals as a means to effectively reduce operating costs and remain competitive in their industry.

Participation in the Climate Wise program continues to increase as companies are informed of the numerous industry specific energy efficiency opportunities and related savings that such opportunities may achieve. Established in 1994 with the enrollment of energy intensive Charter Partners such as DuPont, Lockheed Martin, Georgia Pacific, and Dow Chemical, the program's enrollment increased 7 fold from 1995 to 1996. Based on this Partnership increase, Climate Wise seeks to recruit an additional 1,270 companies by the year 2000.

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