CONCEPT PAPER FOR DISCUSSION

Strategies to Achieve a Reduction in Greenhouse Gas Emissions From Glass Manufacturing Facilities

Introduction

The Air Resources Board (ARB) has the primary responsibility for reducing greenhouse gas (GHG) emissions in California under the Global Warming Solutions Act of 2006 (AB 32). The overall mandate is to achieve 1990 GHG emission levels by 2020. In our efforts to reduce GHG emissions mandated by AB 32, ARB staff is currently working on multiple sector-specific GHG activities. The glass manufacturing plants are a source of GHG emissions and have been identified as a potential subcategory under the business/industry sector. ARB staff is evaluating possible strategies that the glass manufacturing industry can implement to achieve GHG emission reductions. This concept paper will give an overview on the industry and summarize the strategies that ARB staff will be evaluating.

Industry Overview

Some of the largest glass plants in the United States (U.S.) are located in Ohio, Pennsylvania, California, Texas, New York, Kentucky and North Carolina. There are four major segments in the glass manufacturing industry which are separated by the type of end products generated. These segments include container glass, fiberglass, flat or float glass, and pressed or blown glass (also known as specialty glass). In California, there are about five container glass manufacturing plants, four fiberglass manufacturing plants, four flat or float glass manufacturing plants, and about four specialty glass plants.

The glass manufacturing companies in California vary in size and range from small privately held companies to large multinational corporations. Production and consumption for all four segments of the glass manufacturing industry are often concentrated near U.S. population centers due to very high shipping costs of both raw materials and products, and the heavy concentration of end-use customers. The container glass segment is the industry's largest producer, manufacturing about 1.4 million tons of products in 2006 in California.[1] This segment produces bottles, jars, and other containers that compete with alternative materials such as plastic, aluminum, steel, and paper. As a result of past mergers and consolidation to maintain competitiveness, the make-up of the container glass segment has changed drastically through the years. In California, the number of container glass plants has reduced from 11 in 1994 to 5 in 2006.

The flat glass segment is estimated to be producing about 0.2 million tons of products a year in California, with residential and commercial construction and automotive industries comprising most of the market. Other products from this segment include mirrors, instrumentation gauges, and architectural items such as table tops and cabinet doors. Flat glass production is highly dependent on the fluctuating economic cycles of its primary market industries. The industry has become increasingly global, with a rise in foreign ownership of U.S. facilities as well as increased U.S. participation in overseas plants.

The fiberglass segment is composed of two distinct sub-industries: insulation, which is often referred to as glass wool, and textile/reinforcement fibers, which are continuous fiber strands used to reinforce plastics and other materials important to the transportation, marine, and construction industries. The insulation sub-industry manufactured about 0.39 million tons of products in 2006 in California.[2] Similar to flat glass, fiberglass production is greatly affected by the economic cycles of its primary markets: the construction, automotive, and marine industries.

The specialty glass segment is very diverse and consists of traditional products, such as lighting, cookware, and television glass components along with newer products such as fiber optics, photonics, flat screen displays, and liquid crystal display (LCD) panels. Specialty glass producers face varying degrees of competition. Although there are few alternative materials for products such as television tubes and LCDs, the electronic glass segment faces strong challenges from foreign producers, particularly in Europe and Asia. Traditional products such as tableware and cookware face considerable competition from alternative materials (ceramics, stainless steel) as well as from foreign producers.

<u>GHG Emissions Inventory</u>

Glass manufacturing is an energy intensive industry because of the amount of heat that is required primarily to melt raw material and recycled glass (cullet) to produce glass products. A preliminary assessment of the glass manufacturing industry shows that their use of natural gas, electricity, and raw material in their glass making processes contribute toward GHG emissions.

In glass manufacturing, natural gas accounts for nearly all purchased fuels and is the primary fuel used in the melting and annealing processes. Electricity is typically used as booster energy in melting tanks and throughout the plant for lights, fans, pumps, compressed air systems, and forming equipment.

Based on the latest natural gas inventory from the California Energy Commission for flat, container, specialty glass facilities, together with an estimate of the natural gas usage by the fiberglass facilities, the estimated natural gas usage for the glass manufacturing industry in California was 12,700,000 Million British Thermal Units (MMBtu) in 2006. The estimated electricity used by this industry in California is 3,700,000 MMBtu in 2006. The amount of GHG emissions in California due to the industry's energy usage is 0.9 million metric tones of CO_2 equivalents ($MMTCO_2e$) in 2006. A direct source of GHG emissions from the glass manufacturing industry is the CO_2 produced by the decomposition of two of the raw materials: soda ash and lime stone. This is estimated to be 0.1 $MMTCO_2$ in 2006. Therefore, the total amount of GHG emissions from the glass manufacturing industry in 2006 was about 1 $MMTCO_2e$.

Current Local, State, and Federal Regulations

The California glass manufacturing industry has been subjected to various regulations through the years. There are federal regulations on the glass manufacturing industry that regulate the emission of toxic air contaminants (TACs) and/or criteria pollutants. Local California air districts have either incorporated these regulations or have been granted equivalency and given authority to implement district rules to reduce emissions of criteria pollutants and TACs from fiberglass manufacturing plants and criteria pollutants from all other glass manufacturing plants. In addition, California Beverage Container Recycling and Litter Reduction Act (CA Beverage Container Recycling Program) and Fiberglass Recycled Content Act of 1991 require glass container manufacturers in California to use at least 35 percent cullet in their products and fiberglass manufacturers that manufacturer or sell in California to use at least 30 percent cullet in their products. The Department of Conservation is the agency that implements the Bottle and Can Recycling Law and the Fiberglass Recycling Content Act of 1991.

Potential Strategies to Achieve GHG Emission Reductions

ARB staff is in the early stages of evaluating the glass manufacturing measure, but has at this point determined that the best strategy in reducing GHG emissions can be to reduce energy consumption by increasing the amount of cullet used, using other technologies to improve process efficiency, using emission control technologies, and, if appropriate, using alternative sources of energy. The staff has identified several potential approaches that can be adopted for a glass manufacturing measure. These approaches include a direct regulation, a voluntary program, an incentive-based program, or a market-based program.

- Direct Regulation: Adopt regulatory standards that require additional amount of cullet used in glass manufacturing. In addition, a regulation can also require facilities to use best available control technologies (BACT) or adopt energy efficient operation and maintenance procedures for manufacturing glass. With currently known technologies, this approach may achieve a goal of 8 to 15 percent reduction in GHG emissions by 2020.

- Voluntary Program: Work with the glass manufacturing industry in California to promote a voluntary measure to increase the production and use of reusable bottles, increase the use of cullet and/or other energy efficient processes that would also be cost effective. There is no specified incentive under this approach. With currently known technologies, this approach may achieve a goal of 6 to 10 percent reduction in GHG emissions by 2020.

- Financial Incentive Programs: If funding is available, encourage the use of increased cullet, the use of BACT and/or energy efficient operations and maintenance procedures through financial incentives. Again, using currently known technologies, this approach may achieve a goal of 6 to 12 percent reduction in GHG emissions by 2020.

- Nonmonetary Incentive Program: If other resources are available, such as discounted equipment, free energy audits, and/or discounts on energy bills due to the use of BACT, they maybe used to encourage the use of increased cullet, the use of BACT, and/or energy efficient operation and maintenance procedures to reduce energy usage. This approach may achieve a goal of 6 to 12 percent reduction in GHG emissions by 2020.

- Market Based Program: Establish a GHG emission limit. Excess GHG emitted would need to be mitigated by purchasing credits from another glass manufacturer if available. This approach, a form of cap and trade, may achieve a goal of 8 to 15 percent reduction in GHG emissions by 2020.

Technology

Several technologies may be considered under any of these potential strategies. They include: maximize cullet use, optimize melting operation which includes: changes to the existing furnace, furnace design considerations, consideration of oxy-fuel furnace, and cullet and batch preheating, and optimize other operations. These are discussed individually below.

- Maximize Cullet Use: Currently, the glass container manufacturers are required to use 35 percent cullet while the fiberglass manufacturers are required to use 30 percent cullet for their production. According to a Department of Conservation report, the 2006 statewide average recycled content for bottle production was 37.3 percent, while that for fiberglass production was 36.4 percent.[1] The glass container manufacturing industry and others estimate that each percent increase of cullet use can decrease energy consumption by 0.2 to 0.5 percent. In addition, increased cullet use leads to decreased use of carbonate raw materials, which would further reduce the amount of greenhouse gas produced in the process. Another benefit to increased cullet use is the increase in furnace life and the decreased waste that would go into landfills.

  An increase in cullet use may require more available cullet that meets specifications. If this is the case, the additional cullet needed maybe obtained via increased efficiency in the overall recycled glass processing system. For example, this may require more optical sorters at Materials Recovery Facilities (MRFs), improved processing lines, etc. An added benefit of this strategy is the likely GHG reduction due to reduced transportation for the glass currently collected that ends up in landfills. Another potential avenue for additional cullet is an increase in the recycling rate of glass containers.

- Optimize Melting Operation: The melting operation is the most energy intensive step in a glass manufacturing process. There are several methods to optimize the melting operation to reduce energy consumption for this process and they are listed here.[3]

  a. *Changes to Existing Furnaces:* This may include installation of control systems for the melting operation, minimize excess air and reduce air leakage, use of pre-mixed burners, application of adjustable speed drives on combustion air fans, capturing waste heat from flue gases by the use of waste heat boilers, use of bubblers to improve heat transfer, and type and position of the burners. These ideas may or may not be applicable to each individual glass manufacturing facility depending on the application and the status of the existing furnace being used. Potential energy savings is between 0 to 11 percent of the process.

  b. *Furnace Designs:* At the time of furnace replacement or rebuilt, certain furnace designs can help reduce energy consumption. For example, considerations may include: end-fired furnaces versus cross-fired furnaces, various design features of the regenerative furnaces if regenerative furnace is the furnace of choice, possibility of increasing the size of the regenerator to improve heat recovery efficiency, and the latest technologies for the application.[3]

  c. *Oxy-Fuel Furnaces:* About 30 percent of U.S. glass furnaces now use oxygen enriched air. The energy savings of converting to an oxy-fuel furnace depends on the current furnace's energy use, use of electric boosting, air leakage, glass type, and cullet use. The savings may vary between 5 to 45 percent (45 percent for replacing energy inefficient furnaces). Cost effectiveness varies widely and depends strongly on location–specific circumstances, such as the current system's fuel efficiency, costs of NOx emissions, cost of fuel, and cost of electricity.[3]

  d. *Batch and Cullet Preheating:* If the facility is not already doing it, one of the ways to improve energy efficiency can be to preheat batch and/or cullet if the process allows. Cullet preheaters are separated into direct or indirect preheaters depending on whether the cullet is in direct contact with the flue gas. In a cullet-preheater, the waste heat of the fuel-fired furnace is used to preheat the incoming cullet batch. Energy savings of cullet preheaters are estimated to be between 12 and 20 percent. Batch preheating is more difficult than cullet preheating, as clumping of incoming materials can affect the product quality and melter efficiency.[3]

- Optimize Other Operations: In addition to the melting operation, other operations within a glass manufacturing facility may potentially be optimized to reduce energy usage.

Cost and Cost Savings

The estimated costs and economic impacts of a regulatory or voluntary glass manufacturing measure have not been fully evaluated. However, cost impacts from a glass manufacturing measure could impact a facility's operating and maintenance costs and energy costs. It is expected that a measure may result in added costs for purchasing a larger amount of cullet, and added operating and maintenance costs or equipment costs if they are required to use more efficient controls and/or new technology. However, it is also expected that there would be a cost savings due to the decrease in energy usage as well as a decrease in the purchase of raw materials. There appears to be a general agreement, at least within the glass container manufacturing industry, that the use of cullet is cost effective when there is sufficient quality cullet available. Cost for optimizing a glass manufacturing facility's operations will vary greatly depending on the facility's existing equipment and operational practices. Once the California glass manufacturing facilities' current practices are better assessed, the cost impact and cost effectiveness of a measure can be better analyzed.

Expected Reductions

Depending on the strategies and technologies chosen, it is estimated that a potential GHG emission of between 6 to 15 percent may be achieved. In that case, this would result in a total GHG emission reduction of between 0.06 to 0.15 $MMTCO_2e$.
In addition to emission reductions of GHG, benefits of a glass manufacturing measure include reductions in emissions of criteria pollutants, including NOx, SOx, PM, and VOCs, and potential reductions in emissions of some TACs because of the reduction in energy and raw material use. Due to the potential increased use of cullet, the glass manufacturing measure may also reduce waste diverted to landfills.

Potential Issues or Concerns

There are several issues that staff is aware of if one of the potential strategies is put in place. Any of these strategies would increase the demand for cullet, and ARB staff is aware of the industries concerns over the lack of high quality cullet needed to meet the existing requirements. The lack of cullet is one of the major reasons glass manufacturing plants do not use greater quantities of cullet. In general, the glass container manufacturing industry agrees that the use of cullet is cost effective when there is sufficient quality cullet available.

Another issue may be costs associated with the potential requirements for technology upgrades or the use of BACT. The cost impact of such a requirement has not been fully evaluated. If the cost of the required technology is too high, it is possible that it may then be more economical for some companies to make glass containers out-of-state where there are lower standards than to make the required plant upgrades. These issues have not been fully evaluated, but because this measure may offer cost savings through the use of BACT and energy efficient operation and maintenance procedures, we can use financial incentives to encourage facilities to upgrade their technologies.

References

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5. Glass Industry Technology Roadmap, Glass Manufacturing Industry Council, and Office of Industrial Technologies, April 2002.