2009 Glass Manufacturers Surveys
Summary of Selected Results

Background

Assembly Bill 32, the Global Warming Solutions Act of 2006 (Núñez, Chapter 488, Statutes of 2006) creates a comprehensive, multi-year program to reduce greenhouse gas (GHG) emissions in California, with the overall goal of reducing statewide emissions to 1990 levels by the year 2020. This program, as outlined in Health and Safety Code (H&S Code), commencing at Section 38500, directs the ARB to take actions to achieve the maximum technologically feasible and cost-effective reductions of GHG emissions from sources in California. Glass manufacturing plants were identified as a source of GHG emissions. In 2008 ARB staff began an evaluation of potential strategies that the glass manufacturing industry can implement to achieve GHG emission reductions. Staff found that the glass manufacturing processes are energy intensive, where energy used for melting raw material in the furnaces or melters contributes a significant portion of the energy usage in the overall process.

In February 2009, ARB staff conducted a survey of the Glass Industry. This paper presents a summary of selected results from the three 2009 Glass Manufacturers Surveys conducted by ARB. The three surveys: the Flat Glass Manufacturers Survey, the Container Glass Manufacturers Survey, and the Fiberglass Manufacturers Survey, cover three major sectors of the glass industry. The surveys were designed to obtain facility energy usage information, furnace specific operating and maintenance information, energy usage and cost information for years 2005 to 2007.

There are thirteen glass manufacturing facilities operating in California. Three of these facilities are flat glass manufacturing facilities; five are container glass manufacturing facilities, four are fiberglass manufacturing facilities, and a specialty fiberglass facility. All thirteen glass manufacturing facilities provided survey responses to ARB. The focus of this summary is on glass technologies, energy use, and glass production for all facilities except for the specialty fiberglass facility because it is significantly different from the others in product and process.

All three glass manufacturing processes have been characterized by the five steps that are involved in the manufacturing process. These steps include: batch preparation, melting, refining, forming, and post-forming processes.

Flat Glass Manufacturing Processes

The flat glass products are mainly used in the construction and automotive industries. Final products of the flat glass industry include windows, glass doors, windshields, and other similar products. There is more than one method in forming flat glass; however, flat glass is usually formed by a float process where the molten glass floats on a bed of

molten tin during part of the manufacturing process. California's flat glass facilities all use the float process.

There are three flat glass plants operating three continuous furnaces in California. Based on conversations with the flat glass manufacturers, their glass products are relatively homogeneous and therefore, their process efficiency may be evaluated and compared based on the amount of glass pulled. The most energy intensive step of the flat glass manufacturing process is the melting and refining step in the furnaces. All the furnaces in operation use natural gas as fuel and are either side-port, regenerative furnaces or oxy-fueled furnaces. These California furnaces do not use electric boost and over ninety percent of the natural gas used in the manufacturing plants is used as fuel in the furnaces.

Container Glass Manufacturing Processes

The container glass products are primarily used for packaging food and beverages. Differences in the manufacturing processes are due to differences in the technologies used.

There are five container glass manufacturing facilities operating 15 furnaces in California. Although differences in color may impact energy usage slightly, the products are relatively homogeneous and process efficiency may be evaluated and compared based on the amount of glass pulled. The most energy intensive step of the container glass manufacturing process is the melting step in the furnaces. Over seventy percent of the facilities' natural gas usages is used in the natural gas furnaces.

The furnaces in operation may be separated broadly by their fuel type. There is only one electric furnace in operation in California. The other 14 furnaces are similar in that they are all natural gas furnaces with electric boost. Of these 14 furnaces, seven are oxy-fueled furnaces, six are side-port regenerative furnaces, and one is an end-port regenerative furnace.

Fiberglass Manufacturing Processes

The fiberglass product is used for housing insulation. While the general steps in the fiberglass manufacturing processes are the same, the technologies used are quite different in the manufacturing facilities in California. In particular, the HERM (stands for Horizontal collection, Electric melt, Rotary attenuation, and Modular design) process, invented and used by Johns Manville, is significantly different from the others.

There are four fiberglass manufacturing plants operating in California. Although the melting step still contributes significantly to the total amount of energy consumed during the manufacturing process, the proportion of energy used during this step is lower than the flat and the container glass manufacturing processes. In addition, three out of the four fiberglass facilities use electricity as fuel and only one facility uses natural gas as fuel for melting.

Differences in the California fiberglass manufacturing processes included differences in the furnaces and the use of the HERM process. The furnaces used include one oxy-fueled furnace and three electric cold-top furnaces. The HERM process uses six electric melters for the melting step. Johns Manville's response to the survey stated two main differences between the HERM process and the traditional rotary process that is used in the other three facilities. The first difference is the glass melting technology; there is no forehearth required in the HERM process. The second difference is that the HERM process is designed to use pressurized air to attenuate the glass fibers to their desired length and diameter while natural gas is used in the traditional process. Because of the decrease in natural gas usage in the HERM process, there is a corresponding decrease in heat during the manufacturing process which decreases PM production and therefore emissions reduction over the uncontrolled traditional process.

Calculated Greenhouse Gas Emissions

The greenhouse gases emitted from the glass manufacturing facilities include emissions from combustion of natural gas used in the facility and the carbon dioxide emissions due to combustion of the carbonaceous raw material. Therefore, estimates of greenhouse gas emissions from the glass manufacturing facilities were calculated by summing the contributions of natural gas and contributions from the carbonaceous raw material. The amount of carbon dioxide equivalent (CO_2E) from natural gas usage is calculated by multiplying the amount of natural gas usage by the emission factor of 53.02 kg CO_2/MMBtu (Regulation for the Mandatory Reporting of Greenhouse Gas Emissions, Appendix A (page A-6)). The amount of CO_2E from the raw carbonaceous raw material usage is calculated by multiplying the amount used by the appropriate emission factor. The emission factors are: 0.41492 ton CO_2/ ton of soda ash, 0.43971 ton CO_2/ ton of lime stone and 0.47732 ton CO_2/ ton of dolomite (Table U-1 of the Federal Greenhouse Gas Reporting Rule, 40 CFR part 98, subpart U). The calculation, together with the emission and conversion factors, is shown in equation 1.

Equation 1:

Estimated CO_2E Emitted (MMTCO2E) =

Natural Gas Usage (MMBTU) X 53.02 kg CO_2E/MMBTU X 10^{-9} MMT/kg
+
Soda Ash used (T) X 9.072 X 10^{-7} MMT/T X 0.41492 TCO_2E/T Soda Ash
+
Lime Stone used (T) X 9.072 X 10^{-7} MMT/T X 0.43971 TCO_2E/T Lime Stone
+
Dolomite used (T) X 9.072 X 10^{-7} MMT/T X 0.47732 TCO_2E/T Dolomite

Where: MMBTU = million British thermal units
MMTCO2E = million metric ton of carbon dioxide equivalent
T = ton
TCO_2E = ton of carbon dioxide equivalent

The calculated average annual greenhouse gas emissions per facility and the average per facility electricity usage for each of the three glass manufacturing categories are shown in Table 1.

Table 1. Estimated Average Amount of GreenHouse Gas Emissions[1]

Company Name	**Company Type**	**Estimated yearly average of CO_2E Emitted 2005 to 2007 (MT[3]/Company/Year)**	**Yearly average per facility of electricity used 2005 to 2007[4] (Mwh[3]/Company/Year)**
Guardian Industries Corp.[2]	Flat	102,000 (75,000 from NG[3])	52,000
PPG Industries, Inc	Flat		
Pilkington North America, Inc.	Flat		
Owens-Brockway Glass Container – Oakland	Container	94,000 (69,000 from NG)	111,000
Owens-Brockway Glass Container Inc. – Tracy	Container		
Gallo Glass Company	Container		
Saint-Gobain Containers, Inc.	Container		
Owens-Brockway Glass Container Inc. – Vernon	Container		
Owens Corning	Fiberglass	37,000 (32,000 from NG)	116,000
CertainTeed Corporation	Fiberglass		
Knauf Insulation GmbH	Fiberglass		
Johns Manville	Fiberglass		
UPF Corp.	Specialty Fiberglass	---	---

1. Values rounded to the nearest thousand.
2. Used fuel oil in 2005-2007; estimated CO_2E is based on natural gas usage reported for 7 months in 2008; electricity in the same period is average.
3. MT – metric ton, Mwh – megawatt-hour, NG – natural gas
4. Some facilities have included electricity used to generate oxygen for oxy-fuel furnaces.

The yearly average amount of glass pulled per facility for each of the three glass manufacturing categories is shown in Table 2.

Table 2. Amount of Glass Pulled from the Glass Manufacturing Facilities[1]

Company Name	**Company Type**	**Yearly average per facility of glass pulled 2005 to 2007 (Ton/Company/Year)**
Guardian Industries Corp.[2]	Flat	212,000
PPG Industries, Inc	Flat	
Pilkington North America, Inc.	Flat	
Owens-Brockway Glass Container – Oakland	Container	308,000
Owens-Brockway Glass Container Inc. – Tracy	Container	
Gallo Glass Company	Container	
Saint-Gobain Containers, Inc.	Container	
Owens-Brockway Glass Container Inc. – Vernon	Container	
Owens Corning	Fiberglass	99,000
CertainTeed Corporation	Fiberglass	
Knauf Insulation GmbH	Fiberglass	
Johns Manville	Fiberglass	
UPF Corp.	Specialty Fiberglass	---

1. Values rounded to the nearest thousand.
2. Used fuel oil in 2005-2007; estimated CO_2E is based on natural gas usage reported for 7 months in 2008.