Appendix C:
New and Modified Product-Based Benchmarks

Greenhouse Gas Benchmarks

Greenhouse gas (GHG) benchmarks are metrics that enable the comparison of GHG performance across similar industrial facilities. As described in staff's Initial Statement of Reasons (ISOR) for the Cap-and-Trade Regulation, GHG emissions intensity benchmarks are a key part of the calculation methodology to determine the annual number of free allowances allocated to each eligible industrial facility in the Cap-and-Trade Program[1]. There are two methods of benchmarking: 1) product-based benchmarking (PBB) and 2) energy-based benchmarking (EBB). A product-based benchmark is a function of the quantity of GHGs released per unit of industrial product output. A generic form of a product benchmark is shown in Equation 1.

Equation 1. Example Product Benchmark Formula

$$GHG\ Benchmark = \frac{Emissions\ (tonnes\ CO_2e)}{Output\ (tons)}$$

In the energy-based approach, the benchmark is a function of how many GHGs are emitted to produce the energy that is used at a facility. A generic form of an energy-based benchmark is shown in Equation 2. An energy-based benchmark is based on: 1) boiler efficiency which is set at 85%, and 2) fuel choice, set at natural gas.

Equation 2. Example Energy-Use Benchmark Formula

$$GHG\ Benchmark = \frac{Emissions\ (tonnes\ CO_2e)}{Energy\ Used\ (MMBtu)}$$

A distinct difference between PBB and EBB is that PBB is updating while EBB is fixed. The amount of free allocation for PBB is updated annually based on the recent production level whereas it remains constant for EBB at a historical baseline level. This is the primary reason why PBB is ARB's preferred approach in order to incentivize continued/increased production in California. Resolution 11-32 directs Staff to continue working to include more sectors in the PBB methodology. As part of the efforts, ARB contracted with Ecofys and UC Berkeley/Northwestern University to acquire adequate engineering knowledge to develop benchmarks for the sectors that have complex processes such as refineries and food/beverage processing.

[1] See ISOR, Appendix J: http://www.arb.ca.gov/regact/2010/capandtrade10/capv4appj.pdf

General Benchmarking Process

Staff reached out to both the sectors currently subject to the EBB and the sectors identified to be newly entering the program to assess the feasibility of developing PBBs. The assessment included 3 steps: 1) acquire a sound technical understanding of manufacturing process, 2) evaluate the potential number of product units to benchmark, and 3) consult with the covered facilities/stakeholders to determine if sufficient data would be available to construct robust benchmarks.

Throughout the process, Staff applied the below principles to ensure that new benchmarks would be developed in a manner consistent with the existing benchmarks.

1. One product, one benchmark
   - Product unit definition is not differentiated by technology, fuel mix, size, age, climatic circumstances or raw material quality.
   - When a set of products undergoes a similar set of processing steps but may be refined to different levels, use Equivalence Factors (EF) to normalize the target content of the product[2].
2. Use data years that are representative of normal operation years
   - The benchmark should be set using data years with normal operational conditions so that the value is not affected by factors irrelevant to the operational efficiency. Therefore years with any abnormal events should be excluded from the calculation. Examples of abnormal events are maintenance, temporal shutdown, or change in the operation due to the external factors uncontrollable by the operator.
   - Unless any abnormal events are identified, data years 2008-10 should be used because 1) ARB has Mandatory Reporting Regulation data to ensure the rigorousness of the data quality (2009 and 10 data are verified), and 2) it levels the playing field with the sectors with existing benchmarks for which 2008-10 data were used primarily. Since efficiency tends to improve over time, using the same years across the board ensures that the efficiency improvements are taken into account in the fair and equal manner.

Staff proposes to establish new product-based benchmarks for the following sectors:

- Diatomaceous earth mining and processing
- Aluminum and aluminum alloy billet manufacturing
- Iron foundry
- Forging and stamping
- Lead acid battery recycling
- Onshore natural gas processing plants

[2] Example of this includes tomato paste: whereas the targeted content is tomato solids, different products can contain different level of moisture. See Page 7 of this Appendix for detailed description of EF.

- Food and beverage processors (tomato processing, poultry processing, dehydrated flavor processing, sugar beet refining, juice manufacturing, snack chips manufacturing, dairies and pistachios/almond processing)

Sector-by-Sector Benchmark Product Proposal

This section provides the description of the product, manufacturing process, number of covered entities under the Cap-and-Trade Program and proposed product unit on a sector-by-sector basis.

Diatomaceous earth (NAICS 212399)

Diatomite is a chalk-like, soft, friable, earthy, very fine-grained, siliceous sedimentary rock comprised of fossilized diatom remains. Diatomite deposits form from an accumulation of amorphous hydrous silica cell walls of dead diatoms in both oceanic and fresh waters. These microscopic single-cell aquatic plants (algae) contain an internal, elaborate siliceous skeleton consisting of two frustules (valves) that vary in size from less than 1 micrometer (μm) to more than 1 millimeter in diameter but are typically 10 to 200 μm in diameter. The frustules have a broad variety of delicate, lacy, perforated shapes, including cylinders, discs, feathers, ladders, needles, and spheres (U.S. GS 2011). Due to the difference in the habitat, freshwater diatoms have different characteristics than marine diatoms. After mining, diatom ore is dried, milled and then calcined to make different products.

There are 2 diatomite miner/processors subject to the Cap-and-Trade Program and there is one processor of freshwater diatomaceous earth. Staff collected data for freshwater diatom filter aids and proposes to define the product unit as following:

- Short ton of freshwater diatomite filter aids

Aluminum and aluminum alloy billet manufacturing (NAICS 331314 Secondary Smelting and Alloying of Aluminum)

Metal billets are a length of metal that has a round or square cross-section that is manufactured via casting. To create aluminum and aluminum alloy billets, scrap aluminum consisting of aluminum, aluminum alloys, and alloying ingredients is melted, and cast into billets. Following melting and casting operations, billets may undergo additional processing such as heat treatment.

There is one aluminum and aluminum alloy billet manufacturer subject to the Cap-and-Trade program. Staff proposes to define product unit as following:

- Short ton of aluminum and aluminum alloy billet

Iron Foundry (NAICS 331511)

Foundries manufacture castings by pouring metal melted in a furnace into a mold of a desired, and potentially intricate, shape. Achieving the same detail of form as a casting would require extensive tooling and shaping of metal from a mill (US EPA 2002).

There is one iron foundry subject to the Cap-and-Trade program that manufactures ductile iron pipes.

At a pipe manufacturing facility, iron is melted in the cupola furnace at approximately 1,550 °C using scrap steel and recycled materials. In order to obtain ductile cast iron, the iron is injected in the converter with a magnesium alloy. Pipes are then manufactured from the injected iron using a centrifugal casting process. The pipes leave the centrifugal casting shop and are annealed at 960 °C. All pipes are then given a zinc or zinc-aluminum casing (Duktus 2013).

Staff proposes to define product unit as following:

- Short ton of ductile iron pipes

Forging and stamping (NAICS 33211)

Forging is the process of heating metals to a forging temperature well below the melting temperature and then forming the parts through a series of mechanical operations. Different finish product types would require different numbers of processes.

There are 2 forging companies in California that are above or close to 25,000 MT CO2e annual emission threshold to determine the applicability for the Cap-and-Trade Program. There is also a potential of new entrants at a later time. There is no known stamping operator in California subject to the Cap-and-Trade Program.

In general, forging can be grouped in 4 categories: impression die, cold die, open die and seamless rolled ring. Staff obtained data for seamless rolled ring, but not for other types of products due to the fact that the shape, size and metal property of the end products heavily depend on the customer specifications.

Based on the product data ARB obtained, Staff proposes to define product unit as following:

- Short ton of seamless rolled ring

Lead acid battery recycling (NAICS 331492, Subpart R: Lead Production)

Lead is a metal used to produce various products such as batteries, ammunition, construction materials, electrical components and accessories, and vehicle parts. Approximately, 89 percent of lead is used to produce batteries.

A secondary lead smelter produces lead and lead alloys from lead-bearing scrap metal. The incoming lead scrap materials are first pre-treated to partially remove metal and nonmetal contaminants. The resulting lead scrap is smelted using either a blast furnace or reverberatory furnace. The molten lead from the smelting furnace is refined in kettle furnaces, and then cast into ingots or used to produce lead alloy products (US EPA 2009).

There are 2 lead acid battery recyclers that are projected to be newly subject to the Cap-and-Trade Program.

Staff proposes to define the product unit as following:

- Short ton of lead and lead alloy

Onshore natural gas processing plants (NAICS 211112)

Staff proposes to define product units as follows:. Barrel of Gas Processed Equivalent

Please see the discussion in “Modifications to existing benchmarks” section below for detailed information.

Food and beverage sector (NAICS 311, 312120 and 312130)

The Cap-and-Trade Program covers the following food processing sectors: tomato processing, poultry processing, dehydrated flavor processing, sugar beet refining, juice manufacturing, snack chip manufacturing, dairy processing, pistachio and almond processing. It also covers beer, wine and spirits from the beverage sector.

Engagement of external expertise

Food and beverage processing are complex systems to benchmark because one type of input can go through series of process steps to end up in a variety of products. Facilities commonly produce several different products by utilizing complex processing that incorporates the exchange of mass and heat among processing lines. It requires sound engineering understanding of the manufacturing process in order to develop robust benchmarks.

ARB contracted with Ecofys and UC Berkeley/Northwestern University to provide additional expertise. The ongoing project (The Project) under this contract has been conducting full analyses working with stakeholders and covered facilities to develop technically sound benchmarks for the food and beverage sectors. The process descriptions and resulting product definitions described below rely on work done by The Project team. A report may be released at a later date describing all the technical details that supported the Staff proposals for product definitions for the food and beverage sector.

General approach

As described earlier, Staff followed three main steps to develop product-based benchmarks for all sectors, including the food and beverage sectors. Each step included a substantial amount of work to overcome the challenges associated with the complex manufacturing processes unique to the food/beverage sector including:

- Facilities often manufacture many different food/beverage products using a number of energy intensive processes.
- Fuel is often combusted in a central boiler and process heat is moved around the facility as steam for use in plant manufacturing processes.
- Many facilities lack the sub-metering necessary to easily quantify how much energy from the central boiler should be assigned to different products.
- It is common for various final products to have shared upstream thermal processing.

1) Acquire sound technical understanding of manufacturing process

As an initial step, the Project conducted an extensive literature review, including academic research, legislation, and industry publications. The research team also visited eight covered food processing facilities to ensure that the research was based on the actual processing configurations of the plants subject to the Cap-and-Trade Program. On- and off-site interviews were conducted with plant managers and operators to learn about the processes, equipment, and energy involved in making specific food products.

Staff found that PBB development becomes more difficult with increasing process heterogeneity and decreasing process monitoring, especially considering the sub-metering of energy use at each process level. Staff also found that the level of process heterogeneity varied for different food processors, and the quality of process monitoring varied at an individual facility level.

2) Evaluate potential number of product units to benchmark

Based on the information collected through step 1, the research team characterized six typical process configuration types commonly used in the food and beverage sector. This characterization became the basis to determine the methodology to allocate facility-wide energy consumption to each product and to determine which products should be given separate benchmarks and which products should be grouped. The description of each process configuration is shown below.

a) Linear Process Lines

A linear process is a single process line with a single product output. This is the most straightforward processing configuration. Although the inputs to the process may go through multiple process steps, the energy intensity of an output can be derived by dividing total energy input by the amount of output since there is only one product output.

b) Mixing Process Lines

A mixing process line is very similar to a linear process line. However, a mixing process line has multiple raw material inputs which are processed separately before being mixed to produce a single final product. Since only one product is manufactured, the energy intensity can be calculated by dividing total energy by the amount of output. It is critical to include the energy from all the mixing lines as part of the total energy.

c) Parallel Process Lines

Parallel process lines are independent linear processing lines that run parallel. The product output of parallel process lines may be the same or different. Determining the energy intensity for a parallel configuration is straightforward if the thermal use for each line is quantified separately. When no energy sub-metering for each linear process is available, a sound engineering estimate of the distribution of energy between the lines has to be applied.

d) Branching Process Lines

A branching process line yields several final products from a single raw material stream. Products manufactured in a branching process may undergo thermal processing before and after process stream splits. Common processes may be shared by multiple products at any point of the processing. The difficulty arises when a common process does not have the capability to split the energy consumed by each end product. For example, pasteurization can be used by both cream and butter or evaporation by powdered and condensed milk. It becomes essential to combine energy meter readings available at a plant or unit level with estimated theoretical energy requirements for different products to calculate total energy consumption by each product.

e) Formulated Process Lines

Formulated process lines yield multiple products from multiple processed or raw materials. The key step that distinguishes a formulated process line is the combination of these materials into different products at different ratios, each of which may undergo additional processing. This type of facility is challenging because the different formulations of the product may contain ingredients with very different energy intensities. There can also be hundreds of different products with different percentages of different ingredients. Instead of trying to create individual benchmarks for each formulation, benchmarks can be set for each ingredient. For example, instead of a benchmark for a recipe of 20% diced tomatoes and 80% tomato paste, benchmarks can be set for diced tomatoes and tomato paste. This allows Staff to develop benchmarks for a small number of inputs that can be applied to a wide range of reformulated products.

f) Hybrid Process Lines

Hybrid processing includes a combination of the previously discussed configurations. Product definitions can be developed using the approaches for the individual types of lines.

Additional Consideration

For some products in the food processing sector, the same processing line may be refined to different concentrations. Other products may undergo a concentration or shearing process that results in the loss of mass. These situations presented complications in determining product definitions because concentration or shearing processes lead to a loss of product mass and higher levels of thermal concentration require increased thermal input. Staff proposes to apply Equivalency Factors (EFs) to normalize the difference in emission intensity among similar products undergoing concentration or mass loss steps. An example is tomato paste. Instead of differentiating aseptic tomato paste that has different solid content, Staff proposes to normalize it at 31% tomato soluble solids for all aseptic tomato paste. This allows equitable energy efficiency comparison among different paste with different solid content while maintaining one-product, one-benchmark principle. This approach allows for the different concentrations of products to be expressed in terms of an equivalent output in one product definition. This is a reasonable approach to avoid the situation where benchmarks need to be developed for each individual concentration of a given product.

3) Consult with the covered facilities/stakeholders for data collection to construct product-based benchmarks

Once product were defined, Staff worked with covered facilities and/or trading associations that represent covered sectors to start collecting production and energy consumption data from facilities. Staff proposes the following product definitions:

Table 1: Proposed Product Definition for Food Sector (NAICS 311)

Dairy	Dehydrated Flavors	Poultry
Milk, buttermilk and skim milk	Dehydrated onions	Whole Chicken & Chicken Parts
Cream	Dehydrated garlics	Poultry Deli Products
Butter	Dehydrated peppers	Poultry Protein Meal
Sweetened condensed milk and evaporated milk	Dehydrated parsleys	
Powdered Milk	Dehydrated spinach	
Concentrated milk		
Cheese		
Lactose		
Dry Whey Protein Concentrate		
Deproteinized whey		
Snacks & Chips	**Sugar**	**Tomatoes**
Fried Potato Chips	Granulated-refined sugar	Aseptic tomato paste
Baked Potato Chips		Aseptic whole/diced tomato
Corn Chips		Non-aseptic tomato paste
Corn Curls		Non-aseptic whole/diced tomato
Pretzels		Non-aseptic tomato juice
		Canned non-tomato additive
Pistachios/Almonds		
Pistachios		
Almonds		

Table 2: Proposed Product Definition for Beverage Sector (NAICS *312120 and 312130)*

Breweries	Wine, Spirits & Concentrates
Lager beer	Distillate products Grape juice concentrate Liquid color concentrate Crystal color concentrate Activin

Modification to the Existing Benchmarks

Staff reviewed the existing benchmarks to ensure that they were used the best approach and most appropriate data. . Several sectors submitted comments to ARB requesting benchmark review: oil and gas extraction, tissue, boxboard, flat glass, container glass and cold steel rolling.

As part of the review process, staff worked with stakeholders to 1) recalculate the existing benchmarks to ensure all the supporting data were correct and calculated appropriately, 2) collect more extensive/detailed data to perform further analysis if necessary, and to 3) identify any abnormal events that skewed the benchmark making it non-representative of normal operation years. Below is sector-by-sector description of the issues and proposed changes.

Oil and gas extraction

For the upstream oil and gas extraction sector (NAICS codes 211111 and 211112), staff proposed revisions to the existing product-benchmarks for thermal EOR crude extraction, non-thermal crude extraction, and natural gas liquid extraction. In addition, staff also proposed a new benchmark for onshore natural gas processing plants that process greater than 25 million standard cubic feet of natural gas per day (MMscf/day).

Staff proposes to define product unit for large gas processing plants as the following:

- Barrel of Gas Processed Equivalent

Staff initiated a voluntary data collection survey in order to reassess the benchmarks for the upstream oil and gas extraction sector. This survey was distributed in late 2012 to all covered facilities emitting over 25,000 tons CO_2e that extract and process oil and gas, including dry gas, and/or natural gas liquids. All covered facilities in California successfully responded to the survey request; thus all covered entities are represented in the proposed benchmarks for this sector.

The existing benchmark for non-thermal crude extraction included production and emissions from both small (<25 MMscf/day) and large (>25 MMscf/day) gas processing plants. Under the proposed benchmarks, the emissions and production for small gas plants are still included in the non-thermal benchmark as they are considered the same facility as the onshore production facility by definition under MRR. The emissions from the large gas plants are now included in the new benchmark for onshore natural gas processing plants, as they are considered separate facilities under MRR. The rationale to keep the large gas plants as separate facilities derives from stakeholders' requests to maintain consistency between MRR and USEPA's GHG Mandatory Reporting Program. The total allocation for the sector remains the same whether there is a gas processing benchmark or whether the emissions from the large gas plants are included in the non-thermal benchmark.

Under the proposed benchmarks, small gas processing plants would receive an allocation using the proposed non-thermal production benchmark. Large gas processing plants would receive an allocation for their gas processed using the proposed natural gas processing benchmark; allocation for oil and gas production would be based on the proposed non-thermal production benchmark. As a result of the new data received as part of the voluntary data collection survey, all three existing benchmarks for thermal, non-thermal, and natural gas production went down slightly.

Tissue manufacturing

There are two tissue manufacturers subject to the tissue benchmark. One company commented that it produced premium quality tissue products that did not compare directly to the products that the other facility produced. While it is true that the two facilities use different technologies to produce different types of tissue products with different qualities, staff believes that the functionality of the product is still the same: to absorb water. The difference in quality comes from the structure of the paper that determines the ratio of the fiber and the void. More water can be absorbed if there are more voids that are structured to better hold water. Staff believes that this difference can be normalized by comparing the mass of tissue product that holds the same amount of water. Applying the concept of Equivalent Factor (EF), staff proposes to change the product unit from the short ton of tissue to the short ton of tissue that holds the same units of water by using the following calculation:

> Tissue produced adjusted by water absorption capacity = tissue produced (air dried short ton) x weighted grams of water absorbed by weighted gram of tissue product

Weighted water absorbency capacity was quantified by sampling total 6 products that 2 companies produce using ISO 12625-8:2010 as a test method. Two laboratories conducted the test: one third-party lab and ARB's Monitoring & Laboratory Division.

Staff was also able to collect complete base year data from the two participating companies.

Staff proposes to modify tissue product unit from short air dried to of tissue to short air dried ton of tissue produced adjusted by water absorbency capacity.

Recycled Boxboard

Staff reviewed the recycled boxboard benchmark and identified that longer data periods made the benchmark more representative. Staff also identified that an abnormal event in the year

2010. Staff proposes to modify recycled boxboard benchmark using additional data years and excluding 2010.

Flat glass

The flat glass benchmark was developed using data from an ARB-conducted industry survey in 2009 and maintained extensive data/information for process equipment, production and emissions.

One company commented that the existing benchmark was not reflective of the actual details of their operation and requested a review. Staff examined all the data that supported the current benchmark and found that there were some assumptions that needed to be validated and also identified some erroneous calculations. In order to set the benchmark values based on the most accurate data available, staff solicited complete datasets from the three flat glass companies. After reviewing the data, staff concluded that two years should be excluded due to abnormal events at some facilities. Staff proposes to revise flat glass benchmark excluding those two years and correcting the calculations.

Container glass

The container glass sector has commented that the current benchmark that uses the data year 2009 was not appropriate because it did not recognize early actions taken by the facilities. ARB's benchmark stringency principle is that the early actions are already recognized in the benchmark in the way that they always contribute to outperform their peers and reduce compliance obligation. Nonetheless, staff reviewed the data by working with the stakeholders who provided ARB with complete data sets for the year 2005-10. This time staff was able to obtain cullet consumption data that was not available when the existing benchmark was established. Cullet (recycled glass) plays a major role in reducing GHG emission from the glass sector because it can replace virgin feedstock such as soda ash and/or limestone which liberates CO2e through calcining process.

Staff identified that the consumption of cullet at five container glass facilities fluctuated substantially at an individual facility basis whereas the aggregated trend showed continued increase of cullet use per unit of glass produced. According to CalRecycle's Biannual Report of Beverage Container Sales, Returns, Redemption & Recycling Rates[3], the amount of glass recycled at a state-wide level continued to increase until 2008 and started declining marginally after 2009. Various factors such as economic health of collecting activities or the quality of collection can contribute to this trend which is not a linear increase. Staff agrees that the supply of cullet may not be controllable by purchasing facilities and believes that using more years would address the temporal fluctuation of the cullet use. Staff proposes to use a wider range of data years for container glass to account for this wide variability.

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[3] The report is available at: http://www.calrecycle.ca.gov/bevcontainer/Rates/BiannualRpt/default.htm

Steel cold rolling

Steel cold rolling has multiple processes with different energy requirements. USS-POSCO Industries (UPI) provided new and more accurate data to allocate facility-wide emissions to each process and associated output. After reviewing, staff made some adjustments to the emissions assigned to each production process based on UPI's new data. Staff also excluded one year from UPI's dataset since there was equipment maintenance that affected the reading of natural gas metering. Staff proposes to modify the benchmark for pickled steel, cold rolled and annealed steel, galvanized steel and tin coated product. Since there are 2 facilities under steel cold rolling, staff applied either weighted average x 90% or best in class to make sure at least one facility would achieve the benchmark.

Gypsum

Staff proposes to change benchmark unit definitions for gypsum tobe consistent with the Mandatory Reporting Requirements. The overall approach and the benchmark values for gypsum sector are not changed.

Cement

Using biogas is a viable option for covered entities to reduce GHG emissions. Staff is proposing to modify the benchmark for cement sector to take into account biomass consumed on-site. This is consistent with other sectors that combust biogas.