Appendix B: Development of Product Benchmarks for Allowance Allocation

What are Greenhouse Gas Benchmarks?

Greenhouse gas (GHG) benchmarks are metrics that enable the comparison of GHG performance across similar industrial facilities. Benchmarks can be used to establish performance standards, set voluntary targets, or as a basis for free allocation in a market-based system such as cap-and-trade.

As described in staff's Initial Statement of Reasons (ISOR) for the Cap-and-Trade Regulation, product-based greenhouse gas 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] This approach will be used to allocate approximately 95 percent of the allowances given to industrial facilities in 2013 and 31 percent of the total amount of 2013 allowances.

Allocation Using Product Benchmarks

Beginning with the 2011 data year, each facility allocated to under this approach will submit verified product output data to the Air Resources Board (ARB) as part of the mandatory greenhouse gas reporting program.[2] ARB will use this product output information to allocate allowances to the facility using the following general equation:

$$\text{Allocation} = \text{Output} \times A \times B \times C$$

Where:

"Output" is the amount of product produced
"A" is the assistance factor as determined by the leakage risk of the product
"B" is the product benchmark
"C" is a factor that declines in proportion to the overall cap decline

The focus of this paper is on the derivation of the "B" term for each leakage-exposed industrial product. Facilities may receive allowances for more than one product. If a facility produces two different leakage-exposed products, the number of allowances allocated to this facility will be the sum of the amount that would be allocated under each of the two benchmarks individually.

---

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

[2] See the requirements for product reporting in the ARB Proposed Amendments to the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions.

Product Benchmark Construction

In developing product-based benchmarks, staff attempted to create a uniform framework that could be applied across all industrial products facing a leakage risk. This process involved three steps: (1) selecting appropriate industrial products, (2) examining emissions and expected carbon costs, and (3) setting benchmark stringency.

Selecting Appropriate Industrial Products

The ease of developing product-based benchmarks depends on the homogeneity of products within the benchmarked industrial sectors. To develop benchmarks that create the correct incentives for GHG emissions reductions, staff relied upon the "one product, one benchmark" principle. This means that, in most cases, staff believes it is appropriate to avoid benchmarks differentiated by technology, fuel mix, size and age of the facility, climatic circumstances, or raw material quality. Ensuring that all GHG emissions-abatement options remain viable (including switches to different technologies, fuels, inputs, etc.) is an integral part of developing an effective product-based benchmarking approach.

To determining appropriate product metrics for each sector, staff analyzed California's manufacturing activities during the development of the ISOR.[3] Some of the product metrics selected for the current benchmarks remain unchanged from Table 9-1 of the ISOR regulation draft.[4] However, some updates and additions have been made; see Table 9-1 of the current regulation version for revisions.

Examining Emissions and Expected Carbon Costs

As explained in the ISOR, minimizing leakage through free allocation requires an understanding of carbon costs faced by each industrial facility. Direct carbon costs (proportional to direct greenhouse gas emissions) need to be evaluated and adjusted for any indirect carbon costs or carbon cost recovery.[5] For example, if energy is purchased by a facility, an indirect carbon cost may be incurred due to the price of this purchased energy. Conversely, if energy is sold by a facility, some carbon costs will be recovered in the price of the energy sold.[6]

In the development of the product benchmarks, adjustment factors were used to account for the carbon costs embedded in energy flows as shown in Table A.

---

[3] See ISOR, Appendix J, pages J-37 through J-50.

[4] See ISOR, Appendix A: http://www.arb.ca.gov/regact/2010/capandtrade10/capv1appa.pdf

[5] See ISOR, Appendix J, page J-20.

[6] Some carbon costs may also be recovered if the facility is able to increase the price of the industrial product. This type of recovery of carbon cost is recognized in the assistance factor, rather than in the benchmark term.

Table A. Adjustment Factors to Account for Indirect Carbon Costs and Carbon Cost Recovery

Energy Type	Adjustment Factor	Basis	Applied To
Heat	0.0663 metric ton $CO_2e/MMBtu_{heat}$	Assumes that an 80% efficient natural gas boiler sets the carbon cost recovery rate in the market for heat.	Heat sold and heat purchased
Power	0.431 metric ton CO_2e/MWh	Assumes that a 42% efficient natural gas plant sets the carbon cost recovery rate in the power market.[7]	Power sold only[8]

Benchmark Stringency: 90% of Average or Best-in-Class

Staff believes that benchmark stringency should reflect the emissions intensity of highly efficient, low-emitting facilities within each sector. In the ISOR, staff described a targeted level of stringency created by evaluating each industrial sector's production-weighted average emissions intensity during a historical base period and targeting the benchmark to allocate 90 percent of this level per unit product.[9]

In the subsequent work of evaluating the benchmark values, staff found that the stringency approach proposed in the ISOR worked for many sectors but, in some cases, would set the benchmark at a level that was more stringent than the current emissions intensity of any existing Californian facility. For the sectors for which this occurred, staff selected a benchmark based on the "best-in-class" value (i.e., the emissions intensity of the most GHG-efficient California facility).

Staff's approach may be compared to product benchmark stringency in the European Union's Emissions Trading Scheme (EU ETS). For the third phase of the EU ETS (2013-2020), benchmarks were developed based on a value reflecting the average greenhouse gas performance of the 10 percent best performing installations in the EU producing that product.[10] The EU Commission describes this choice of benchmark stringency as follows:

---

[7] This assumption is equivalent to the lowest level of carbon cost recovery guaranteed in the Qualified Facilities and Combined Heat and Power Settlement (CHP settlement). Documentation available from: http://www.pge.com/b2b/energysupply/qualifyingfacilities/settlement/ (accessed 6/30/2011)

[8] An adjustment factor was not made for power purchased in establishing the product-based benchmarks. This is because purchased power may not create an indirect carbon cost in all California utility service territories. It is ARB's goal to see a carbon price properly embedded in all utility rates. If and when this occurs, the compensation for these indirect carbon costs could be incorporated into the product benchmarks (or reductions in these costs created in some other fashion) to help minimize leakage.

[9] See ISOR, Appendix J, page J-35.

[10] In taking the average of the 10 percent best performers the EU ETS uses an arithmetic mean (with no weighting by production). EU ETS benchmark values are taken from EU Commission Decision of 27 April

> *"Installations that meet the benchmarks (and thus are among the most efficient installations in the EU) will in principle receive all allowances they need. Installations that do not meet the benchmark will have a shortage of allowances and the option to either lower their emissions (e.g. through engaging in abatement) or to purchase additional allowances to cover their excess emissions."*[11]

All California product benchmarks are presented and compared to their EU ETS counterparts in Table B.

2011 (2011/278/EU). Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:130:0001:0045:EN:PDF (accessed 6/30/2011)

[11] Quote taken from the following EU Commission website: http://ec.europa.eu/clima/policies/ets/benchmarking_en.htm (accessed 6/30/11)

Table B. Comparison of California and EU ETS Product Benchmarks

Sector	NAICS code	Activity	CA Benchmark (Imperial Units)		CA Benchmark Units (SI Units)		EU ETS Benchmark (SI Units)	
Crude Petroleum and Natural Gas Extraction	211111	Heavy (API < 20) Crude Oil Extraction	0.0654	Allowances / Barrel of Heavy Crude Oil Equivalent	N/A	N/A	N/A	N/A
		Light (API >= 20) Crude Oil Extraction	0.0100	Allowances / Barrel of Light Crude Oil Equivalent	N/A	N/A	N/A	N/A
Natural Gas Liquid Extraction	211112	Natural Gas Liquid Processing	0.0146	Allowances / Barrel of Natural Gas Liquids Produced	N/A	N/A	N/A	N/A
Potash, Soda, and Borate Mineral Mining	212391	Mining and Manufacturing of Soda Ash and Related Products	0.948	Allowances / Short Ton of Soda Ash Equivalent (Soda Ash, Biocarb, Borax, V-Bor, DECA, PYROBOR, Boric Acid, and Sulfate)	1.045	Allowances / Metric Ton of Soda Ash Equivalent (Soda Ash, Biocarb, Borax, V-Bor, DECA, PYROBOR, Boric Acid, and Sulfate)	0.843	Allowance / Metric Ton of Soda Ash produced

Sector	**NAICS code**	**Activity**	**CA Benchmark (Imperial Units)**		**CA Benchmark Units (SI Units)**		**EU ETS Benchmark (SI Units)**	
Paper (except Newsprint) Mills	322121	Through-Air-Dried (TAD) Tissue Manufacturing	1.30	Allowances / Air-Dried Short Ton of TAD tissue	1.43	Allowances / Air-Dried Metric Ton of TAD tissue	N/A	N/A
Paperboard Mills	322130	Recycled Boxboard Manufacturing	0.499	Allowances / Air-Dried Short Ton of Recycled Boxboard	0.550	Allowances / Air-Dried Metric Ton of Recycled Boxboard	0.273	Allowances / Air-Dried Metric Ton of Coated Carton Board
		Recycled Linerboard (Testliner) Manufacturing	0.468	Allowances / Air-Dried Short Ton of Recycled Linerboard	0.516	Allowances / Air-Dried Metric Ton of Recycled Linerboard	0.248	Allowances / Air-Dried Metric Ton of Testliner and Fluting
		Recycled Medium (Fluting) Manufacturing	0.394	Allowances / Air-Dried Short Ton of Recycled Medium	0.434	Allowances / Air-Dried Metric Ton of Recycled Medium	0.248	Allowances / Air-Dried Metric Ton of Testliner and Fluting
Petroleum Refineries	324110	Petroleum Refining	0.0465	Allowances / Barrel of Primary Refinery Products Produced	N/A	N/A	0.0295	Allowances / Carbon Weighted Metric Ton of Petroleum Product

Sector	NAICS code	Activity	CA Benchmark (Imperial Units)		CA Benchmark Units (SI Units)		EU ETS Benchmark (SI Units)	
All Other Petroleum and Coal Products Manufacturing	324199	Coke Calcining	0.341	Allowances / Short Ton Calcined Coke	0.376	Allowances / Metric Ton Calcined Coke	0.376	Allowances / Metric Ton Calcined Coke
Industrial Gas Manufacturing	325120	Gaseous Hydrogen Production	8.51	Allowances / Short Ton of Hydrogen Gas	8.62	Allowances / Metric Ton of Hydrogen Gas	8.85	Allowances / Metric Ton Hydrogen Gas
		Liquefied Hydrogen Production	TBD	Allowances / Short Ton of Liquefied Hydrogen	TBD	Allowances / Metric Ton of Liquefied Hydrogen	N/A	N/A
Nitrogenous Fertilizer Manufacturing	325311	Nitric Acid Production	0.349	Allowances / Short Ton of Nitric Acid (HNO_3 100%)	0.385	Allowances / Metric Ton of Nitric Acid (HNO_3 100%)	0.302	Allowances / Metric Ton of Nitric acid (HNO_3 100%)
		Calcium Ammonium Nitrate Solution Production	0.0902	Allowances / Short ton of calcium ammonium nitrate solution	0.099	Allowances / Metric Ton of calcium ammonium nitrate solution	NA	N/A
Flat Glass Manufacturing	327211	Flat Glass Manufacturing	0.471	Allowances / Short Ton of Flat Glass Pulled	0.519	Allowances / Metric Ton of Flat Glass Pulled	0.453	Allowances per Metric Ton of Float Glass Exiting the Lehr

Sector	NAICS code	Activity	CA Benchmark (Imperial Units)		CA Benchmark Units (SI Units)		EU ETS Benchmark (SI Units)	
Glass Container Manufacturing	327213	Container Glass Manufacturing	0.264	Allowances / Short Ton of Container Glass Pulled	0.291	Allowances / Metric Ton of Container Glass Pulled	0.275	Allowances per Metric Ton of Glass (Adjusted to Colored Glass Pulled)
Mineral Wool Manufacturing	327993	Fiber Glass Manufacturing	0.394	Allowances / Short Ton of Fiberglass Pulled	0.434	Allowances / Metric Ton of Fiberglass Pulled	0.682	Allowances / Metric Ton of Container Glass Packed (Includes Emissions from Purchased Electricity)
Cement Manufacturing	327310	Cement Manufacturing	0.713	Allowances / Short Ton of Adjusted Clinker and Mineral Additives Produced	0.786	Allowances / Metric Ton of Adjusted Clinker and Mineral Additives Produced	0.716	Allowances / Metric Ton Clinker + 7% Mineral Additives
		Clinker production (EU benchmark for comparison)	N/A	N/A	N/A	N/A	0.766	Allowances / Metric Ton of Grey Clinker Produced

Sector	**NAICS code**	**Activity**	**CA Benchmark (Imperial Units)**		**CA Benchmark Units (SI Units)**		**EU ETS Benchmark (SI Units)**	
Lime Manufacturing	327410	Dolime Manufacturing	1.40	Allowances / Short Ton of Dolime Produced	1.54	Allowances / Metric Ton of Dolime Produced	1.072	Allowances / Metric Ton of Dolime Produced
Gypsum Product Manufacturing	327420	Plaster Manufacturing	0.0454	Allowances / Short Ton of Plaster	0.0500	Allowances / Metric Ton of Plaster	0.048	Allowances / Metric Ton of Plaster Produced
		Plaster Board Manufacturing	0.134	Allowances / Short Ton of Plaster Board	0.147	Allowances / Metric Ton of Plaster Board	0.131	Allowances / Metric Ton of Plasterboard Produced
Iron and Steel Mills	331111	Steel Production Using an Electric Arc Furnace (EAF)	0.170	Allowances / Short Ton of Steel Produced Using EAF	0.199	Allowances / Metric Ton of Steel Produced Using EAF	0.283	Allowances / Metric Ton EAF Carbon Steel (Includes Emissions from Purchased Electricity)
Rolled Steel Shape Manufacturing	331221	Hot Rolled Steel Sheet Production	0.0843	Allowances / Short Ton of Hot Rolled Steel	0.0929	Allowances / Metric Ton of Hot Rolled Steel	N/A	N/A

Sector	NAICS code	Activity	CA Benchmark (Imperial Units)		CA Benchmark Units (SI Units)		EU ETS Benchmark (SI Units)	
		Pickled Steel Sheet Production	0.0126	Allowances / Short ton of Pickled Steel	0.0139	Allowances / Metric Ton of Pickled Steel	N/A	N/A
		Cold Rolled and Annealed Steel Sheet Production	0.0313	Allowances / Short Ton of Cold Rolled and Annealed Steel	0.0345	Allowances / Metric Ton of Cold Rolled and Annealed Steel	N/A	N/A
		Galvanized Steel Sheet Production	0.0504	Allowances / Short Ton of Galvanized Steel	0.0556	Allowances / Metric Ton of Galvanized Steel	N/A	N/A
		Tin Steel Plate Production	0.0197	Allowances / Short Ton of Tin Plate	0.0217	Allowances / Metric Ton of Tin Plate	N/A	N/A
Turbine and Turbine Generator Set Units Manufacturing	333611	Testing of Turbines and Turbine Generator Sets	0.00782	Allowances / Horsepower Tested	N/A	N/A	N/A	N/A

Sector Details

A brief description of the work conducted to derive the product benchmarks are shown below for five selected sectors. These sectors were selected because of total contribution to statewide emissions and because there are enough Californian facilities in these sectors to show benchmarking curves without revealing sensitive facility-specific production information. The sectors with benchmark curves below emitted approximately 91% of 2008 GHG emissions from industrial facilities that will be covered by the Cap-and-Trade Program.[12]

Crude Petroleum Extraction

In the ISOR, staff considered two oil extraction benchmarks differentiated based on the extraction techniques currently used in California. A distinction was made between "thermal" enhanced oil recovery and "non-thermal" extraction methods.[13]

After consideration of stakeholder written comments and discussions with stakeholders on this issue, staff changed the benchmark to use the American Petroleum Institute's gravity metric (API gravity) to differentiate products in the oil production sector. This method results in a benchmark for the production of heavy crude oil (API gravity <20) and a benchmark for the production of light crude oil (API gravity $\geq$20). This recognizes that heavy and light crude oil represent slightly different products.[14]

Staff believes this new approach is more consistent with a focus on products rather than processes in the benchmarking work. The impacts of this change in approach are not believed to be dramatic because most California heavy crude is extracted using thermal techniques and most light crude is extracted using non-thermal techniques. Stakeholders are requested to provide comment on this change.

The benchmark curves for extraction of heavy and light crude oil are shown in Figure 1 and Figure 2.

---

[12] See ISOR Appendix J, Tables J-4 and J-5 for 2008 emissions by sector.

[13] See ISOR Appendix J, page J-38.

[14] Crude oil prices differ to reflect crude quality primarily based on two metrics—API gravity and sulfur content. Therefore, light and heavy crude may be thought of as slightly different products. For a discussion of crude price differentials and differences in crude quality see the following study: http://www.esmap.org/esmap/sites/esmap.org/files/08105.Technical%20Paper_Crude%20Oil%20Price%20Differentials%20and%20Differences%20in%20Oil%20Qualities%20A%20Statistical%20Analysis.pdf (accessed 6/30/11).

Figure 1. Benchmarking Light Crude Oil Extraction

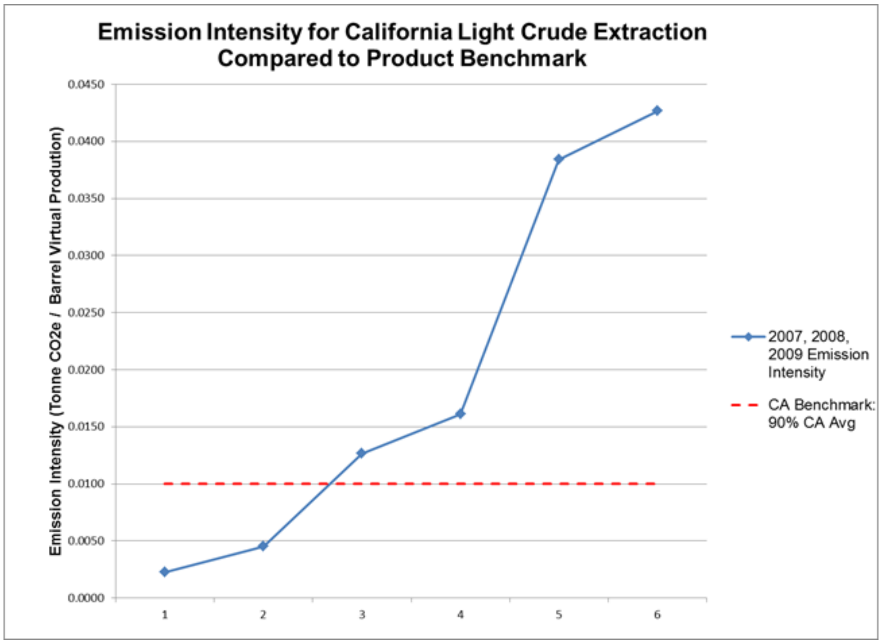
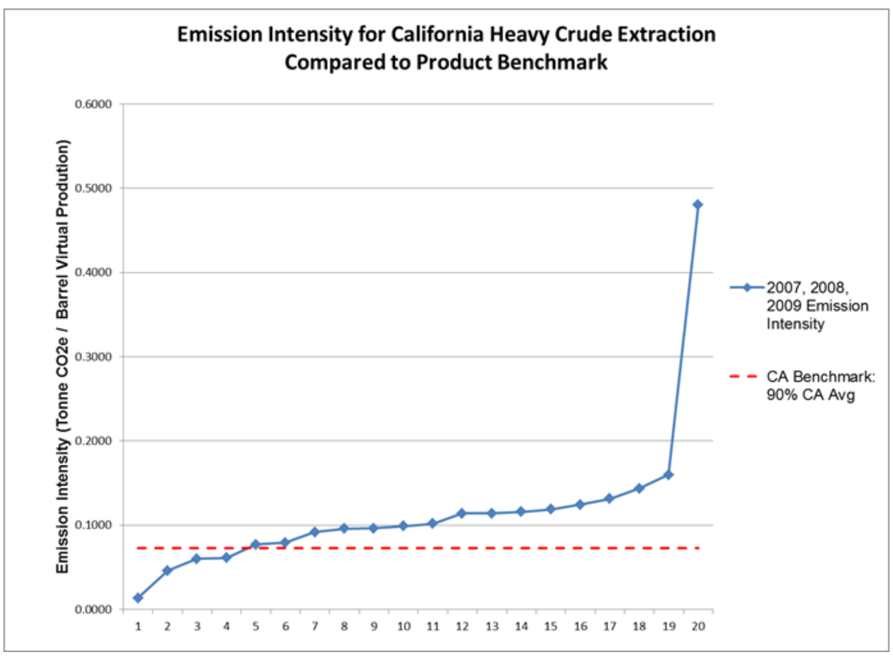


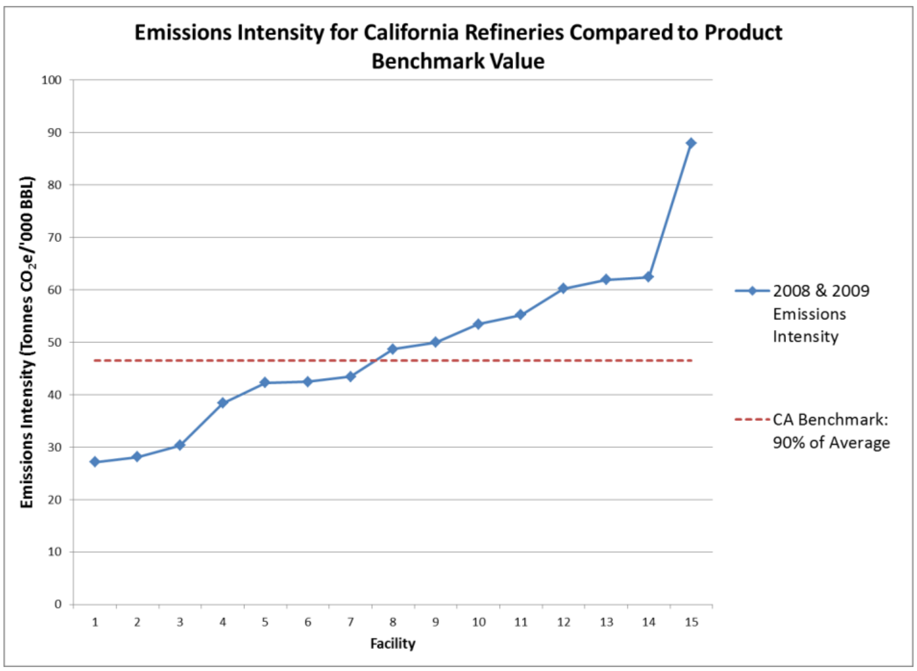
Figure 2. Benchmarking Heavy Crude Oil Extraction



Petroleum Refineries

For the refining sector, a version of the "simple output barrel" benchmark referred to in the ISOR was analyzed.[15] This benchmark is based on the primary products produced by California refineries, including aviation gasoline, motor gasoline, kerosene-type jet fuel, distillate fuel oil, renewable liquid fuels, and asphalt. For the purpose of calculating this benchmark, staff converted blendstocks into their approximate finished fuel volumes by multiplying blendstocks by an assumed blending ratio of 10% by volume. The emissions intensity of California refineries relative to this benchmark is shown in Figure 3.

Figure 3. Benchmarking Petroleum Refinery Production



Staff is still evaluating other refinery-sector allocation approaches, including the Western States Petroleum Association's (WSPA's) proposal for allocation to be based on the following factors: (1) historical emissions from for each refinery, (2) the Solomon Energy Intensity Index (EII) for each refinery, (3) an adjustment factor to reduce competitiveness impacts of allowance allocation between in-state refineries, and (4)

[15] See ISOR Appendix J, pages J-40 through J-43, for a description of the options for allocating to the California refineries.

future emissions for each refinery.[16] Stakeholders are requested to provide comments specific to allocation and the refining sector. Stakeholders interested in the alternative methods are encouraged to contact staff directly.

Industrial Gas Manufacturing (Hydrogen Production)

Closely coupled with the petroleum-refining sector is the production of hydrogen gas. Refiners use large quantities of hydrogen and, in refinery applications, hydrogen exists primarily as an intermediate rather than a final product. Because of this, the ISOR proposed that hydrogen production be included as part of the refining allocation benchmark rather than develop a unique product benchmark for hydrogen (with a unique leakage risk).

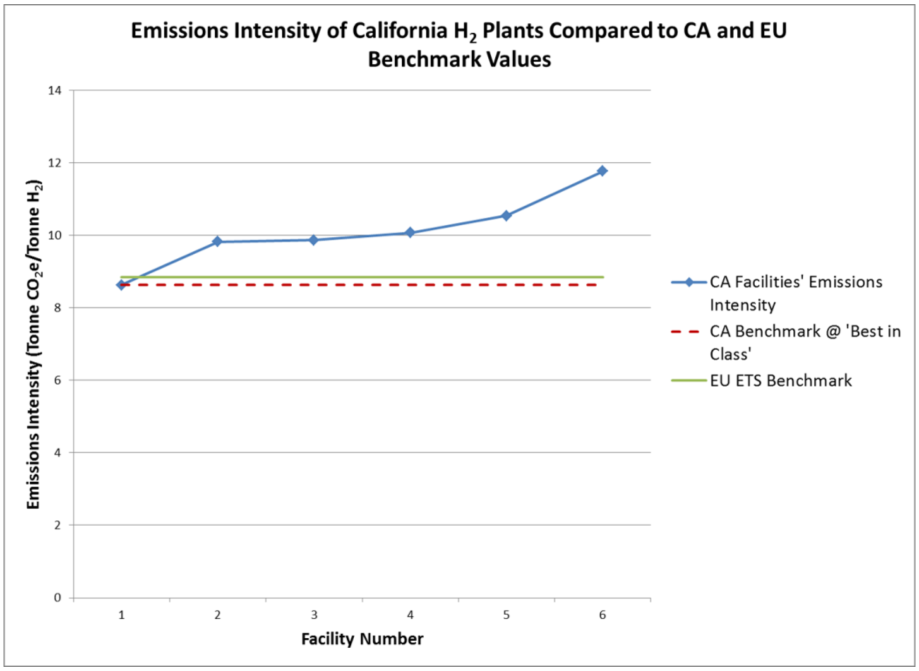
However, at some California refineries the ownership of the hydrogen plant is separate from that of the refinery. Based on comment from independent hydrogen producers and refiners regarding the nature of current agreements and the inability to pass on carbon costs in the price of hydrogen sold, staff is now proposing to separately allocate to each of the independently owned hydrogen plants using a product benchmark based on the amount of hydrogen produced (see Figure 4).

Staff is also considering the need for an additional benchmark based on the amount of liquid hydrogen produced. Stakeholders have commented that the market for liquid hydrogen is different from that of gaseous hydrogen produced in large quantities for sale to refineries (or other co-located stationary sources). The leakage risk for this product might therefore be different than that of gaseous hydrogen. Staff seeks stakeholder comment on this issue.

---

[16] A spreadsheet created by WSPA with example calculations of their preferred allocation approach is posted on the following ARB webpage: http://www.arb.ca.gov/cc/capandtrade/meetings/072011/wspa.xls

Figure 4. Benchmarking Hydrogen Production



Glass Container Manufacturing

Glass production produces GHGs from fuel combustion and from the calcination of carbonate-based raw materials. The production of container glass (bottles, jars, etc.) is the largest emitting subsector of glass production in California.

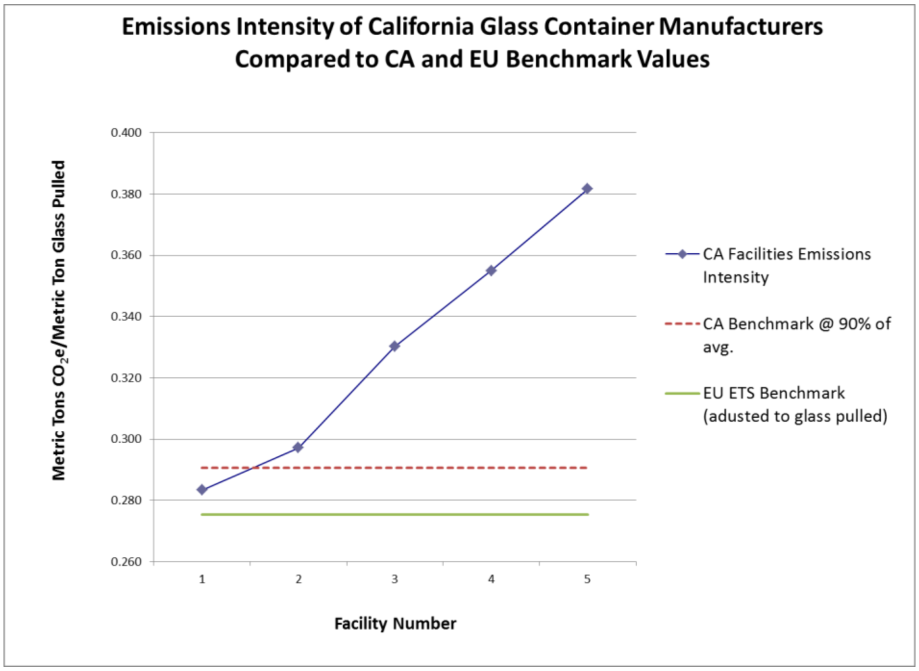
As described in the ISOR, a benchmark for container glass production was created using a “glass pulled” metric. This differs from the “glass packed” approach metric used by the EU ETS, where the output upon which the benchmark is developed is based on the packaged containers rather than the quantity of glass pulled from the furnace. By using the glass pulled approach, ARB is not including post-production handling losses in the quantity term of the benchmark. Since the EU ETS benchmark is based on tons of glass packed, to present a valid comparison the EU value had to be adjusted to represent tons of glass pulled.

The original benchmark documentation produced by the EU ETS assumed a packed-to-melt ratio of 90%.[17] For comparison purposes to the CA benchmark, the EU ETS benchmark for colored container glass (0.306) was adjusted assuming this packed-to-melt ratio to reach the 0.275 value shown in Table B and Figure 5.

---

[17] Methodology for the free allocation of emission allowances in the EU ETS post 2012: Sector report for the glass industry, 2009. No assumptions about packed-to-melt ratios were presented in later documents.

Figure 5. Benchmarking Container Glass Manufacturing



Cement Manufacturing

In the ISOR, staff proposed an output metric based on the level of clinker production at California's cement facilities adjusted based on the average level of mineral additives (gypsum and limestone) in the cement shipped from that facility. Staff has developed a benchmark based on this approach and now refers to this product metric as "adjusted clinker and mineral additives produced." The calculation of this metric is shown in the following equation:

> Adjusted Clinker and Mineral Additives Produced = Clinker Produced x (1 + (Limestone and Gypsum Consumed)/Clinker Consumed))

Use of this benchmark allows for lower-GHG mineral additives to be substituted for cement. Greater use of mineral additives should provide a viable method for California cement facilities to produce the finished product (cement) with fewer greenhouse gases.

In contrast, the EU benchmark is based on clinker produced without consideration of the level of blending with mineral additives. To allow for comparison to California's benchmark, staff has adjusted the EU benchmark assuming a 7% blending ratio (see Table B and Figure 6),

Figure 6. Benchmarking Cement Manufacturing