Cap-and-Trade Regulation:
Proposed Benchmarks for Refineries and Related Industries

Background

The current Cap-and-Trade Regulation includes a refinery benchmark for the second and third compliance period that uses carbon-weighted tonne (CWT) as a proxy for product. In response to a request by the refineries, ARB staff is proposing to use complexity-weighted barrels (CWB) instead. This approach is used in the current proposed amendments to the Cap-and-Trade Regulation. The main differences in the two approaches are that refinery throughputs are reported in barrels versus tonnes and that the CWT benchmark is based on European data while the CWB benchmark uses California specific data and methodologies. The Board is expected to consider the proposed amendments in April with an effective date of mid-2014.

Total refinery CWB is calculated using several dozen types of refinery process units as well as adjustments representing emissions due to off-sites and non-process steam. In mid-2013, California refineries voluntarily reported to ARB historical throughput data for process units and data for the non-process CWB adjustments. ARB double-checked these data with each refinery in early 2014. These data enabled ARB to compare CWB, CWT and actual refinery emissions.

As ARB has received data and input from stakeholders and conducted analyses during 2013 and early 2014, its proposed benchmarks for refineries and related industries have evolved. This document outlines how the current benchmarks were calculated and why they differ from earlier proposals. ARB plans to propose the benchmarks presented here in the 15-day rulemaking package to be released in March.

For more information on allocation, please see Appendix J of the 2010 Cap-and-Trade Regulation rulemaking package, which can be found at:

http://www.arb.ca.gov/regact/2010/capandtrade10/capandtrade10.htm

Standard ARB Benchmarking Approach

ARB sets benchmarks at either 90% of a sector's average greenhouse gas (GHG) emissions per unit product or best-in-class, which means the lowest facility-specific GHG emissions per unit product. The best-in-class benchmark is used when no one facility can meet the 90% average benchmark. The proposed refinery, hydrogen, and calcining benchmarks all follow this approach, and all were set at 90% of the sector average. Details of their calculation are given below.

ARB typically uses 2008-2010 emissions and production data to establish benchmarks. However, ARB does not have 2009 throughput or hydrogen emissions data from refineries, so the refinery CWB benchmarks and the hydrogen benchmark are based only on 2008 and 2010. The calcining benchmark was calculated using data from 2008, 2009 and 2010. Emissions are adjusted to include imported steam and exclude exported electricity and steam.

Hydrogen Benchmark

To ensure program design consistency with ARB's "one product, one benchmark" guideline, a single hydrogen production benchmark, $b_{hydrogen}$, is proposed for merchant and refinery hydrogen production. Hydrogen is considered to be a separate refinery product. Both refineries and independent hydrogen facilities would receive hydrogen production-based allocation under this single hydrogen benchmark, thus providing common incentives among all hydrogen producers. The hydrogen benchmark was calculated as 90% of the sum of all hydrogen production GHG emissions at refineries and merchant facilities divided by the sum of all hydrogen production at refineries and merchant facilities.

$$b_{hydrogen} = 0.9 \times \frac{\sum_{merchant \,\&\, refinery} GHG_{2008} + \sum_{merchant \,\&\, refinery} GHG_{2010}}{\sum_{merchant \,\&\, refinery} Hydrogen_{2008} + \sum_{merchant \,\&\, refinery} Hydrogen_{2010}}$$

Here, GHG_{year} is the annual GHG emissions associated with hydrogen production at a refinery or merchant hydrogen facility, and $Hydrogen_{year}$ is the amount of hydrogen produced (in millions of standard cubic feet) in the given year at a refinery or merchant hydrogen facility. The summations indicate that both emissions and production are summed over all merchant hydrogen producers and refineries that produce hydrogen. Refinery hydrogen data are from the refinery survey, while merchant hydrogen data are from Mandatory Reporting Regulation (MRR) records. MRR data for refineries from 2008 and 2010 do not identify hydrogen production emissions independent from total facility emissions so they could not be used for refinery hydrogen production emissions. A small number of facilities had problems with hydrogen production emissions data reported in the voluntary survey, and both production and emissions data from these facilities were excluded from the calculation.

Aggregate hydrogen production and associated GHG emissions data are presented in Table 1. The data in Table 1 were used to calculate $b_{hydrogen}$ as follows:

$$b_{hydrogen} = 0.9 \times \frac{(9,360,073 + 9,548,261) \; MT \; CO_2 e}{(388,788 + 401,256) \; million \; scf \; H_2}$$

$$b_{hydrogen} = 21.54 \text{ allowances/million scf } H_2 = 8.94 \text{ allowances/MT } H_2$$

Once these calculations were complete, staff confirmed that at least one facility could meet the 90% of average benchmark so this was the appropriate benchmark

Table 1 Sector aggregated hydrogen production and associated GHG emissions

Sector	2008		2010	
	GHG emissions (tonnes CO_2e)	Hydrogen production (million scf)[#]	GHG emissions (tonnes CO_2e)	Hydrogen production (million scf)[a]
Merchant hydrogen	2,108,246	95,287	2,685,568	121,423
Refinery hydrogen	7,251,827	293,501	6,862,693	279,833
Total hydrogen	**9,360,073**	**388,788**	**9,548,261**	**401,256**

[a] Million standard cubic feet at atmospheric pressure and 60 °F.

Previously Proposed Hydrogen Benchmark
The hydrogen benchmark presented at the October 2013 workshop was calculated using a different approach because sufficient data on refinery hydrogen emissions were not available at that time. The equation used was similar to the above benchmark equation but only data for merchant hydrogen facilities were used:

$$b_{hydrogen} = 0.9 * \frac{\sum_{merchants} GHG_{merchant,2008} + \sum_{merchants} GHG_{merchant,2010}}{\sum_{merchants} Hydrogen_{merchant,2008} + \sum_{merchants} Hydrogen_{merchant,2010}}$$

$Hydrogen_{merchant,year}$ and $GHG_{merchant,year}$ are respectively the amount of hydrogen produced and the associated GHG emissions for a merchant hydrogen plant in the given year. The summations are over all merchant hydrogen plants.

The previously proposed benchmark was 20 allowances/million scf H_2. The currently proposed hydrogen benchmark is higher than that proposed in October because refinery hydrogen data are included in the current calculation. The refinery hydrogen producers are on average less emissions efficient than the merchant hydrogen producers, so the benchmark increases when the refinery data are included.

CWB Benchmarks
The CWB benchmarks were calculated using the following procedure:
  1. Refineries were classified as atypical or typical. To be atypical, a refinery must have fewer than 12 process units and also have less than 20 million barrels per year of crude input through its atmospheric distiller. For this purpose, a refinery possesses a process unit if the refinery reported via our voluntary survey a non-

zero throughput for that process unit type. The CWB adjustments for off-sites and non-crude sensible heat are not considered process units for this purpose. All refineries not meeting this definition are classified as typical, including refineries without atmospheric distillers. If a refinery had abnormal operations during 2008 or 2010, its data were excluded from the CWB benchmark calculation entirely. Using this classification scheme there are 13 typical refineries and 4 atypical refineries, with one refinery excluded.

2. The benchmark for typical refineries, $b_{typical}$, was calculated as 90% of GHG emissions summed over all typical refineries divided by CWB summed over all typical refineries. Because refinery hydrogen was included under the hydrogen benchmark, emissions and CWB contributions from hydrogen production were not included in this calculation.

$$b_{typical} = 0.9 \times \frac{\sum_{typical\ refineries} GHG_{refinery,2008} + \sum_{typical\ refineries} GHG_{refinery,2010}}{\sum_{typical\ refineries} CWB_{refinery,2008} + \sum_{typical\ refineries} CWB_{refinery,2010}}$$

Annual greenhouse gas emissions at a refinery, $GHG_{refinery,year}$, are based on mandatory reporting data from 2008 and 2010, adjusted to include emissions from steam imported on-site and exclude emissions from steam and electricity exported off-site during the same year. Steam transferred between merchant hydrogen plants and refineries is treated the same as other steam imported to or exported from a refinery. In addition, $GHG_{refinery,year}$ does not include emissions associated with hydrogen production, unless these data were not reported in the refinery survey.

The annual complexity weighted barrels for a refinery, $CWB_{refinery,year}$, was calculated with refinery provided survey data. $CWB_{refinery,year}$ includes contributions from refinery process units ($CWB_{process,year}$), off-sites ($CWB_{off-sites}$), and non-crude sensible heat ($CWB_{non-crude\ sensible\ heat,year}$), and was calculated using the following equations:

$$CWB_{refinery,year} = CWB_{process,year} + CWB_{off-sites,year} + CWB_{non-crude\ sensible\ heat,year}$$

$$CWB_{process,year} = \sum_{process\ units} (CWB\ Factor_{process\ unit} \times Throughput_{process\ unit,year})$$

$$CWB_{off-sites,year} = (0.327 \times Total\ Input\ Barrels_{year}) + (0.0085 \times CWB_{process,year})$$

$$CWB_{non-crude\ sensible\ heat,year} = (0.44 \times Non - Crude\ Input\ Barrels_{year})$$

Definitions for *Total Input Barrels*$_{year}$, *Non-Crude Input Barrels*$_{year}$, *CWB Factor*$_{process\ unit}$ and *Throughput*$_{process\ unit,year}$ are as described in MRR. The above equations can be combined and simplified to yield:

$$
\begin{aligned}
CWB_{refinery,year} &= (1.0085 \times CWB_{process,year}) + (0.327 \times Total\ Input\ Barrels_{year}) \\
&+ (0.44 \times Non - Crude\ Input\ Barrels_{year})
\end{aligned}
$$

For this benchmark calculation, contributions from hydrogen production were not included in *CWB*$_{process,year}$ unless complete data were not available to allow exclusion. For refineries where problematic hydrogen emissions data led to their exclusion from the hydrogen benchmark calculation, their total emissions (including hydrogen production emissions) and total CWB (including the CWB contribution from hydrogen production) were included when calculating the refinery benchmark.

Aggregate values of *GHG*$_{refinery,year}$ and *CWB*$_{refinery,year}$ are provided in Table 2 for typical and atypical refineries. These values can be inserted into the $b_{typical}$ equation to yield:

$$b_{typical} = 0.9 \times \frac{(24{,}943{,}556 + 23{,}538{,}047) MT\ CO_2 e}{(5{,}770{,}830 + 5{,}485{,}247)\ CWB}$$

$$b_{typical} = 3.88\ \text{allowances/CWB}$$

Once these calculations were complete, staff confirmed that at least one refinery could meet the 90% of average benchmark so this was the appropriate benchmark.

Table 2 Aggregate values of *GHG*$_{refinery,year}$ and *CWB*$_{refinery,year}$ for typical and atypical refineries

Sector	2008		2010	
	GHG emissions (MT CO$_2$e)	CWB (CWB)	GHG emissions (MT CO$_2$e)	CWB (CWB)
Typical refineries	24,943,556	5,770,830	23,538,047	5,485,247
Atypical refineries	502,228	93,873	468,871	79,332
Total	**25,445,784**	**5,864,703**	**24,006,918**	**5,564,579**

3. The benchmark for atypical refineries, $b_{atypical}$, was calculated using the same method as above, but with summation over atypical refineries instead of typical refineries:

$$b_{atypical} = 0.9 \times \frac{\sum_{atypical\ refineries} GHG_{refinery,2008} + \sum_{atypical\ refineries} GHG_{refinery,2010}}{\sum_{atypical\ refineries} CWB_{refinery,2008} + \sum_{atypical\ refineries} CWB_{refinery,2010}}$$

Values for atypical refineries from Table 2 can be inserted into this equation to give:

$$b_{atypical} = 0.9 \times \frac{(502,228 + 468,871)\ MT\ CO_2e}{(93,873 + 79,332)\ CWB}$$

$b_{atypical}$ = 5.05 allowances /CWB

CWB Benchmark Curves

The benchmark curves below show the emissions intensity – emissions attributed to CWB divided by CWB – for each refinery. Both emissions and CWB were calculated for each refinery using the methods described above under "CWB Benchmarks." The refinery with anomalous data that was excluded from the benchmark calculation is also excluded from the benchmark curves.

Figure 1 shows the CWB benchmark curve with refineries ordered on the x-axis from most emissions efficient (refinery 1) to least efficient (refinery 17). Figure 2 shows the same benchmark curve with atypical refineries grouped to the left and typical refineries grouped to the right. Atypical refineries have fewer process units which may contribute to their wider variation in emissions per CWB. These two benchmark curves may be compared to the benchmark curves shown in the October workshop presentation[1].

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[1] http://www.arb.ca.gov/cc/capandtrade/meetings/100713/refinery_workshop_presentation_10_7_13.pdf

Figure 1 CWB benchmark curve with refineries in order of increasing emissions intensity.
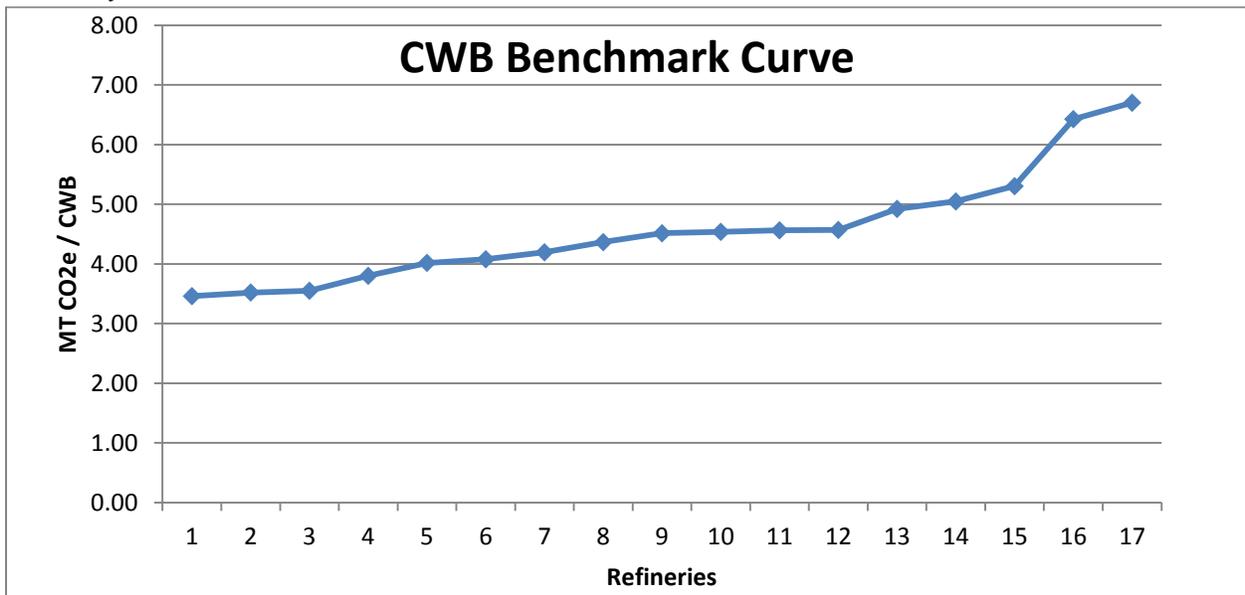
Figure 2 CWB benchmark curve with atypical refineries grouped to the left and typical refineries grouped to the right.
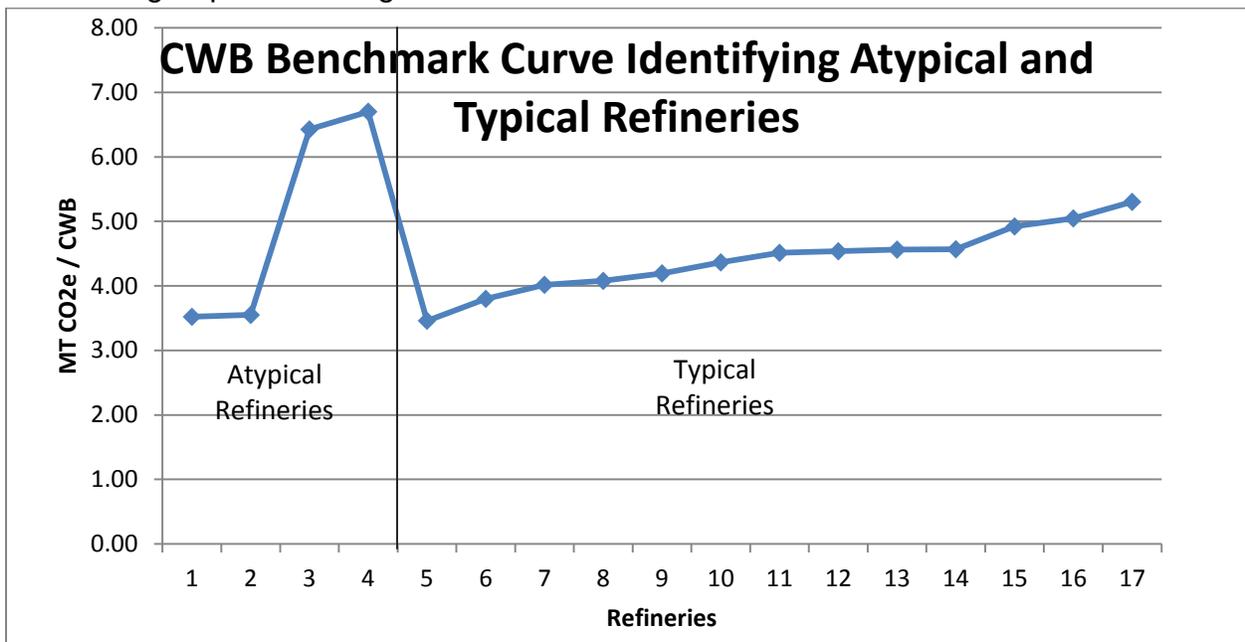
Previously Proposed CWB Benchmarks

ARB has distributed two previous sets of potential CWB benchmarks for refineries: one in the informal regulatory draft posted on the ARB website on January 31, 2014,[2] and one at the October 7, 2013 workshop.[3] These previous proposals, along with the current proposal are summarized in Table 3.

Table 3 Proposed CWB Benchmarks

Refinery Type	Proposed Refinery CWB Benchmarks (allowances/CWB)		
	Oct. 7, 2013 Workshop	Jan. 31, 2014 Informal Draft	Current Proposal
Typical	4.08	3.96	3.88
Atypical	6.78	5.11	5.05

The CWB benchmarks distributed in the informal regulatory draft were 5.11 allowances/CWB for atypical refining and 3.96 allowances/CWB for typical refining. Two changes led to the differences between the informal regulatory draft values and the current calculated values: excluding hydrogen production from the CWB benchmark calculation and data changes based on updated information reported to ARB during the completion of the informal survey. The benchmark calculation now excludes emissions and CWB contributions from hydrogen production, while previous calculations included these because early hydrogen data did not appear reliable. In recent weeks, ARB reviewed survey data with representatives from each refinery to improve accuracy and provide an opportunity for corrections. While checking data, most refineries reported at least one correction. Most corrections consisted of adding refinery throughput data that had erroneously been omitted from earlier reports or increasing values that had been underreported. Therefore, final CWB totals using these data are higher than previously calculated and final CWB benchmarks are slightly lower.

The potential CWB benchmarks presented at the October workshop were larger than those put forth in the informal regulatory draft on January 31, 2014. The October workshop benchmarks were calculated differently than those in the informal regulatory draft. First, they relied on non-reviewed preliminary throughput data. Second, the earlier total CWB calculation included only process CWB and omitted the adjustments for off-sites and non-crude sensible heat, together known as off-sites adjustments. ARB staff inadvertently omitted off-sites adjustments in the calculation results presented at the October 7 workshop. Of the change in the atypical benchmark from 6.78 to 5.11 allowances/CWB, approximately 20% was due to data corrections received from refineries and 80% was due to the omission of off-sites adjustments. For the atypical benchmark's change from 4.08 to 3.96 allowances/CWB, all of the decrease was due to

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[2] http://www.arb.ca.gov/cc/capandtrade/cap-trade-15-day-discussion-draft-01-31-14.docx
[3] http://www.arb.ca.gov/cc/capandtrade/meetings/100713/refinery_workshop_presentation_10_7_13.pdf

the addition of off-sites adjustments to the total CWB calculation, and data corrections contributed a very slight increase.

Calcining Benchmark

The proposed calcining benchmark, $b_{calcining}$, is 0.632 allowances/MT calcined coke. This was calculated using 2008, 2009 and 2010 production and emissions data reported by calciners. The calcining benchmark was calculated by the following equation, in which $ccoke_{calciner,year}$ refers to the amount of calcined coke produced in the given year:

$$b_{calcining}$$
$$= 0.9$$
$$* \frac{\sum_{calciners} GHG_{calciner,2008} + \sum_{calciners} GHG_{calciner,2009} + \sum_{calciners} GHG_{calciner,2010}}{\sum_{calciners} ccoke_{calciner,2008} + \sum_{calciners} ccoke_{calciner,2009} + \sum_{calciners} ccoke_{calciner,2010}}$$

This benchmark is set at 90% of average since at least one of the calciners can meet the benchmark. Since there are only two calciners in California, further calculation details are withheld to protect confidential business information.

Neither the calcining benchmark nor its underlying data have changed since the October 7, 2013 workshop.

Other Expected Changes from the Informal Discussion Draft

"Atypical Petroleum Refining" means petroleum refining at a refinery with less than 20 million barrels of crude throughput through its atmospheric distillers per calendar year as reported and verified under section 95113 of the MRR and fewer than twelve types of process units, of the process unit types listed in the first column of Table 1 of section 95113 of the MRR, except not including "Total Refinery Input" and "Non-Crude Input" as process units. For the purposes of determining whether refining is typical or atypical, any refinery facilities which are "jointly operating" will be evaluated jointly. The total throughput and total number of unique types of process units reported via MRR for the two facilities combined will be used to determine if the jointly operated refineries are atypical. The determination will be made annually.

 "Complexity weighted barrel" or "CWB" means a metric created to evaluate the greenhouse gas efficiency of petroleum refineries and related processes. The CWB value for an individual refinery is calculated using actual refinery throughput to specified process units and emission factors for these process units. The emission factor is denoted as the CWB factor and is representative of the greenhouse gas emission intensity at an average level of energy efficiency, for the same standard fuel type for each process unit for production, and for average process emissions of the process units across a sample of refineries. Each CWB factor is expressed as a value weighted relative to crude distillation. A refinery's CWB value for allocation will be its $CWB_{process}$ value adjusted for off-sites and non-crude sensible heat using the following equation: $CWB = 1.0085*CWB_{process} + 0.327*Total Refinery Input + 0.44*Non-crude Input$. This calculation will rely on data submitted under section 95113 of the MRR.

"Jointly operating" means the condition of two or more refineries which are considered jointly for the purposes of determining if the refinery is atypical. Any refinery whose annual production of primary refinery product, measured by volume, as reported via section 95113 of MRR, is less than 10% of its atmospheric crude distillation throughput for that year will be considered jointly operating with the refinery to which it transfers the greatest volume of output for that year via any mode of transport. If a refinery has no atmospheric crude distillation throughput, then it will be considered jointly with the refinery from which it receives the most inputs by volume via any mode of transport. Any refineries reporting under a single ARB Identification Number under MRR also will be considered jointly operating.

"Typical Petroleum Refining" means all refining at a petroleum refinery which does not meet the definition of atypical petroleum refining.

ARB will add additional text in the regulation to clarify the process for determining jointly operating. ARB will determine if any refinery meeting the throughput and process unit requirements of atypical also meets the jointly operated criteria based on data reported

and verified via MRR section 95113 and will request notification of which refinery it is sending the greatest volume of output to or receiving the greatest volume of input from prior to allocation.

95891. Allocation for Industry Assistance.

(a)(2) Second and Third Compliance Period Refining Sector Allocation. For ~~buget~~ budget years 2015-2020, petroleum refineries shall receive their allocation of allowances pursuant to the product output-based allocation calculation methodology stated in section 95891(b), using ~~carbon weighted tonne or~~ the complexity weighted barrel ~~metrics~~ detailed in ~~the~~ ~~sections~~ 95113(l)(3)~~-(4)~~ of MRR and the following equation: CWB = $1.0085 \times CWB_{process}$ + $0.327 \times$ Total Refinery Input + $0.44 \times$ Non-Crude Input.