Frequently Asked Questions (FAQs)

Updated Aluminum Cans and new Aluminum Ingot material GHG Emission and Energy Factors for WARM version 12

Q1. What are the new "aluminum ingot" energy and emission factors and what could these be used for?

WARM v12 provides aluminum ingot energy and emission factors to allow WARM users to estimate energy and emissions implications of aluminum materials other than aluminum beverage cans. However, these aluminum ingot energy and emission factors do not account for the additional energy consumption and emissions from additional processing beyond aluminum ingot manufacture including conversion from aluminum ingot to end-use application. These additional emissions and energy consumption can be significant. For example, can-making steps for the virgin manufacture of aluminum beverage cans account for about 15 percent of total energy consumption and about 20 percent of total emissions. The contribution of additional processing steps after recycled aluminum ingot production is even greater; these steps account for about 78 percent of both total energy consumption and total emissions for recycled aluminum beverage can manufacture. Therefore, the "aluminum ingot" energy and emission factors should only be used as a conservative proxy for representing aluminum materials other than aluminum cans, e.g., electrical transmission and distribution wires, other electrical conductors, some extruded aluminum products, aluminum product cuttings, joinings and weldings, and aluminum used in consumer durable products such as home appliances, computers, and electronics.[1]

Note that the difference between aluminum cans and aluminum ingot numbers are not a function of the can manufacturing steps alone. Because more than one short ton of ingot is needed to produce a short ton of beverage cans, the additional energy and emissions associated with manufacturing aluminum cans are also a function of the additional amount of aluminum ingot needed.[2] It is important to note that since the life-cycle energy and emission factors for aluminum ingot are developed using industry-specific information from the aluminum beverage can industry, these factors may not directly align with the real aluminum ingot production used for other aluminum applications. Hence, manufacture of

[1] Note that using the aluminum ingot material type as a proxy for the aluminum materials mentioned here does not factor in the energy and emissions associated with the additional processing of aluminum ingot to produce a final aluminum product, which are likely to be quite significant. Thus, the resultant energy and GHG emissions impacts of managing aluminum products as represented by the WARM aluminum ingot factors likely underestimate the true impacts.

[2] Additional aluminum ingot is needed to manufacture one short ton of aluminum cans because some of the metal is lost during the can making steps of stamping, pressing, and trimming. This scrap is shipped to secondary casting facilities.

aluminum goods involving manufacturing steps after aluminum ingot production are likely to have greater emission and energy factors than those provided in WARM for aluminum ingot.

Q2. Why have the energy and emission factors for aluminum cans changed in WARM version 12, and why have the GHG benefits of recycling aluminum decreased?

The energy and emission factors, and hence the greenhouse gas (GHG) benefits of recycling, for aluminum cans in WARM version 12 (v12) are different from previous versions for a number of reasons. The new source of underlying life-cycle data is the main contributor to the changes. Previous WARM versions used aluminum sheet data from Franklin Associates Ltd. (FAL 2002) as the source for process and transportation data and EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (EPA 2005 and 2010) as the source for non-energy process data. WARM v12 uses updated industry-specific life-cycle inventory data including process, transportation and non-energy process data to develop energy and emission factors for aluminum cans (AA 2011, AA 2010 and PE Americas 2010). Key changes affecting the WARM v12 energy and emission factors as a result of this new data set include:

- **Additional can making steps included in updated life-cycle data:** The data for aluminum cans in preceding versions of WARM were based on proxy data from aluminum sheet used in computer manufacturing (FAL 2002). However, the industry data from the Aluminum Association (PE Americas 2010 and Aluminum Association [AA] 2011) includes specific energy and emissions associated with can-making steps, i.e., manufacturing steps beyond aluminum sheet rolling. Hence, the LCA for aluminum cans in WARM v12 incorporates these additional data and correctly aligns system boundaries between what needs to be and what is calculated.
- **Industry-specific electricity grid mix assumptions:** The electric power grid fuel mix used by the aluminum industry is less carbon-intensive than the national average grid mix. Most (roughly 67 percent) of the electricity used by the aluminum industry is composed of hydropower based electricity compared to the national grid (which is comprised of roughly 50 percent coal based electricity). WARM v12 incorporates this aluminum industry-specific electricity grid mix. The effect of this change is a significant reduction in the upstream emissions associated with virgin manufacture of aluminum cans as compared to previous versions of WARM. See FAQ 5 below for more details.
- **Improvements in aluminum industry efficiencies and differences in fuel mix:** The life-cycle data used to calculate the energy and emission factors have been significantly updated since the original data, which were based on aluminum industry activities in the 1990s. WARM v12 contains updated data that reflect current efficiencies in the aluminum industry and therefore present a more accurate picture of fuel use in the aluminum beverage can manufacturing industry. The table below presents the fuel mix breakdown for upstream process energy for 100 percent virgin inputs versus 100 percent recycled inputs for aluminum cans in both the older and updated versions of WARM.

Table 1: Process Energy Fuel Mix for Virgin and Recycled Production of Aluminum Cans for WARM versions 11 and 12.

	Fuel Type	Virgin Inputs		Recycled Inputs	
		WARM 12 (new)	WARM 11	WARM 12 (new)	WARM 11
Process Energy Average Fuel Mix (in Percent)	Gasoline	0.00	0.11	0.00	0.34
	LPG	0.03	0.01	0.20	0.01
	Distillate Fuel	0.00	0.59	0.01	0.49
	Residual Fuel	5.11	1.13	1.51	4.28
	Biomass/Hydro	-	0.03	-	0.04
	Diesel	0.33	0.20	0.18	0.00
	Electricity	80.99	88.50	65.76	45.10
	Coal	1.99	0.69	0.00	0.72
	Natural Gas	11.54	8.57	32.28	48.71
	Nuclear	-	0.16	-	0.27
	Other	0.01	0.02	0.04	0.04
Process Energy Per Ton (MBtus)		**184.74**	**213.33**	**36.24**	**16.59**

– = Zero energy consumption.

As a result of all the changes mentioned above, especially the energy and emissions factor adjustment to industry-specific electricity grid mix and the change in fuel mix, the GHG benefits of recycling, while still positive, are lower than those presented in previous WARM versions.

For more information, please see the documentation ("Metals" chapter) available online at: http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html

Q3. Why are the process non-energy numbers so different?

Process non-energy emissions are non-energy GHG emissions that occur during manufacturing but are not related to consumption of fuel for energy. In aluminum production, non-energy process emissions mainly occur during electrolysis. During electrolysis, most of the carbon from the anode is oxidized and released to the atmosphere as carbon dioxide (CO_2). Emissions also occur in the form of the PFCs (perfluorocarbons), tetrafluoromethane (CF_4), and hexafluoroethane (C_2F_6).

The process non-energy numbers in WARM v12 have increased mainly because of two reasons: (1) a change in source data and (2) increasing efficiencies in the aluminum production process. PFC emissions for earlier WARM versions were calculated using national GHG emissions from EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. Under this previous approach, WARM v11 scaled national PFC emissions estimates (EPA 2005) to a per short ton basis using national aluminum production data from the same source (i.e., EPA, 2005). However, the aluminum life-cycle analysis in WARM v12 directly incorporates current industry-specific emissions data from the Aluminum Association (AA 2010), which were not previously available.

For more information, please see the documentation ("Metals" chapter) available online at: http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html

Q4. Why has transportation energy decreased?

Significant differences are observed in the updated transportation energy and emissions factors due to accounting differences for transportation energy in the different underlying life-cycle data sources. Refer to FAQ 2 above.

Q5: The aluminum industry relies heavily on electricity derived mostly from hydropower. Do the WARM emission factors for aluminum account for this?

Yes. WARM v12 employs industry-specific primary energy consumption and electricity emission factors to account for the electricity consumption profile of the electrolysis and ingot casting steps of the aluminum manufacturing process. The industry-specific electricity accounting was developed by EPA in consultation with the Aluminum Association. Electricity consumption in these manufacturing stages accounts for the vast majority (83 percent) of the electricity consumption during the entire aluminum can manufacturing process. Since this electricity is mainly hydropower-based, the energy and emissions from electricity consumption for aluminum production are much lower than previously estimated in the WARM v11 factors (which utilized U.S. national average electricity grid mix assumptions). Thus, process energy emissions associated with primary aluminum production, though much lower than in previous WARM versions, are more reflective of the aluminum industry's emissions.

For more information, please see the documentation ("Metals" chapter) available online at: http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html

Q6. Why has the total energy consumption for recycled production increased in WARM v12?

For the recycled production, the majority of energy and emissions are associated with can and lid making stages (about 78 percent for recycled manufacture). Because the data used in prior versions of WARM from Franklin Associates Ltd. (FAL 2002) were for aluminum sheet, and not cans, they did not capture these additional unit process life-cycle stages. Thus, the additional energy and emissions from these can-making steps now included in the new factors result in an increase in energy and emission factors for recycled aluminum can manufacture.

References

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