

**GHGs, Carbon Footprints and the Remanufacturing Industry:  
Capitalizing on a Sustainable Advantage**

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Carbon emissions, carbon dioxide, greenhouse gases and climate change. These issues and what to do about them are attracting a tremendous amount of attention today, from international panels of scientists correlating the effects of carbon dioxide on climate change to governmental regulators figuring out how to curb our collective appetite for fossil fuels. But how do these relate to the remanufacturing industry? And how does the remanufacturing industry impact greenhouse gas emissions?

Greenhouse gases, or GHG's, are important because they help regulate the surface temperature of the earth through the "greenhouse effect". With all the discussion about reducing GHG's, one would think that ideally they should be eliminated entirely. However, without them, the earth would be a much colder place. This is because GHGs let heat from the sun in, but they limit heat escaping back out into space. This heat balance has kept the surface temperature pretty comfortable for us during the last tens of thousands of years. In fact, scientists have estimated that if we didn't have any GHGs and the associated greenhouse effect, the earth's temperature would be about 30°C colder than it is today.

So what are the GHGs? Formally, a GHG is any gas that contributes to the greenhouse effect. However, most of the discussion today surrounds those that are highly influenced by man – referred to as "anthropogenic GHGs". These are distinguished from GHGs that result from natural processes. For example, carbon dioxide generated from coal-burning power plants would be considered an "anthropogenic GHG", whereas carbon dioxide generated from a forest fire is a naturally occurring GHG.

We mention carbon dioxide, or CO<sub>2</sub>, because this is perhaps the most significant greenhouse gas and one that is recognized by nearly everyone. But there are several other GHGs of interest, as shown in Table I. These have been defined by the United Nations Framework Convention on Climate Change (“UNFCCC”) as the major anthropogenic GHGs that we need to watch and indeed, reduce over time.

Table I. Natural and Anthropogenic GHGs Measured by the UNFCCC

Greenhouse Gas	Chemical Name	Source
Carbon Dioxide	CO <sub>2</sub>	Natural & Anthropogenic
Methane	CH <sub>4</sub>	Natural & Anthropogenic
Nitrous Oxide	N <sub>2</sub> O	Natural & Anthropogenic
Hydrofluorocarbons	HFC	Anthropogenic
Perfluorocarbons	PFC	Anthropogenic
Sulfur Hexafluoride	SF <sub>6</sub>	Anthropogenic

Note that the terms HFC and PFC represents families of synthetic gases that have similar chemistries.

Over the past decade, most nations have begun measuring and reporting their greenhouse gas inventories. The U.S. Environmental Protection Agency is the responsible governmental body to do this in the U.S., and they recently released their report for 2007. It shows that by far CO<sub>2</sub> emissions are the most abundant, with methane second, as shown in Figure 1.

GHGs from naturally occurring events have dominated the greenhouse effect for most of the planets history. The concern over the last several decades is that increases from anthropogenic GHGs have become a sizable contribution to the overall GHG concentration. In fact, the International Governmental Panel on Climate Change recently reported that a dramatic rise in CO<sub>2</sub> and other GHGs has occurred over the last two hundred years, and was subsequently attributed to man-made effects resulting from energy production (coal-burning power plants), transportation (gasoline and diesel vehicles), and by simply meeting the basic living needs of a much larger global population (food production). Today, the national inventories track GHGs by

source, showing that energy production and transportation are the two largest sources of anthropogenic GHGs, as shown in Figure 2.

Many governments have already started making policy decisions to curb future increases in GHGs. The EU community has established itself as a global leader in defining and executing an effective GHG policy. Several years ago the EU put into place its Emission Trading Scheme, or “ETS”, effectively a carbon cap-and-trade system that monetizes carbon emissions - rewarding those who creatively reduce GHG emissions and financially penalizing those that don't. So far the program has shown modest success, limited largely by how carbon credits were allocated during the first phase of implementation. But now that it is understood how the program works, the next round of allocations is purportedly going to be much more restrictive, thus ensuring a more stable and higher carbon trading price.

In the United States, it is not clear when or even if any policy will emerge in the near future. For instance, in 2009 the US House of Representatives passed the Waxman-Markey Bill, also known as the American Clean Energy & Security Act. The bill encourages low-carbon energy sources, alternative fueled vehicles and energy efficiency measures, but perhaps more strikingly it proposes a carbon cap-and-trade measure to effectively put a price on carbon emissions, much like the EU ETS program. However, in the ensuing 12 months, the US Senate has not been able to agree to a unified direction on energy and climate change, and has all but postponed the discussion until after the November, 2010 elections, implying any meaningful legislative action will not take place until 2011 at the earliest.

While the US Congress attempts to iron out a bipartisan energy and climate change bill, the Environmental Protection Agency has already started to flex its new, GHG regulatory muscle. Recall that in 2009, the EPA was authorized to regulate GHGs due to the gases adverse impact on health and the environment. Shortly thereafter, the EPA teamed up with the National Highway Transportation Safety Administration (NHTSA) to regulate CO<sub>2</sub> emissions from cars and pickup trucks. Moreover, such authority also allows them to regulate stationary sources such as power plants. So one way or another, GHG emissions are on the path to regulation.

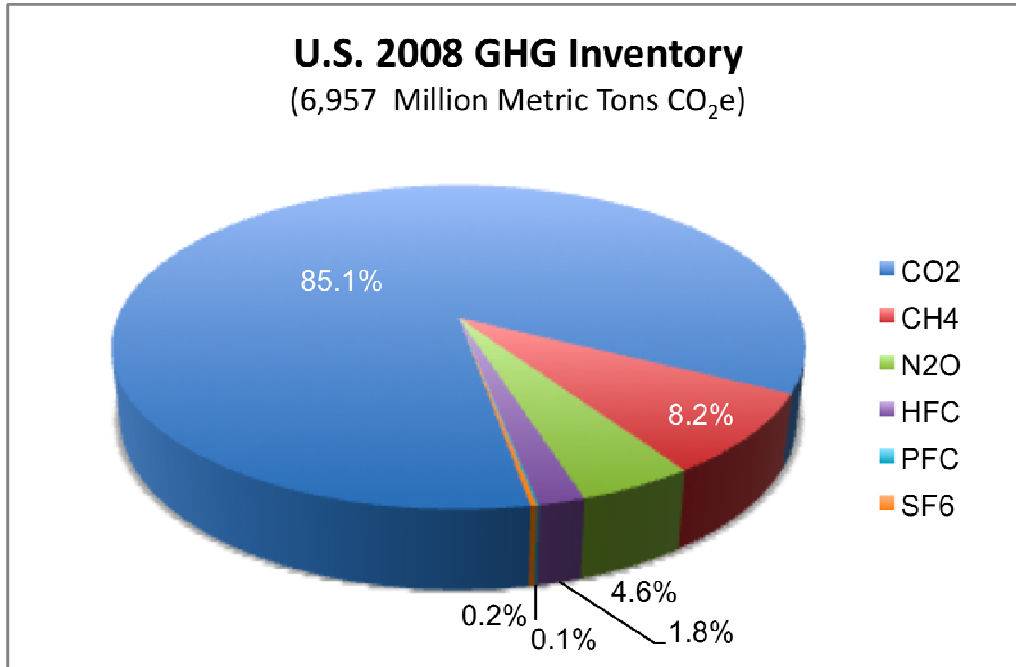


Figure 1. U.S. Inventory of Anthropogenic GHGs, adapted from the EPA's 2008 Report on US Greenhouse Gases & Sinks (EPA 430-R-10-006), published April 15, 2010.

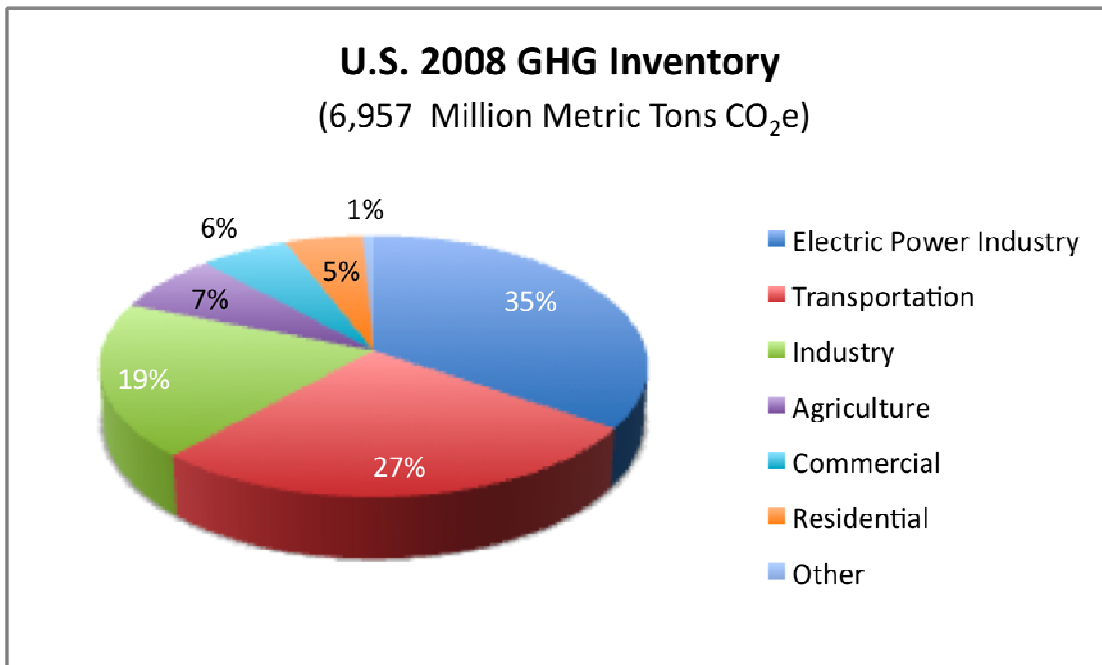


Figure 2. Sources of Anthropogenic GHGs, by Economic Sector. Adapted from the EPA's 2008 Report on US Greenhouse Gases & Sinks (EPA 430-R-10-006), published April 15, 2010.

But the EPA isn't the only one taking action against GHGs. California, ever the indicator for future environmental actions, has already passed AB32, the California Global Warming Solutions Act, which mandates GHG reporting requirements, emission reductions, as well as a carbon cap-and-trade system. This program complements other cap-and-trade programs in the US and Canada, such as the Regional Greenhouse Gas Initiative ("RGGI") among powerplants in the Northeast, and the Western Climate Initiative ("WCI") among several western states and Canadian provinces. So cap-and-trade programs are already in place in the US, but it remains to be seen whether they will be numerous in number and discrete in nature, or whether they will eventually come under a federal umbrella as a single market-based system. Time will tell.

### *GHGs and The Remanufacturing Industry*

What does all of this have to do with the remanufacturing industry? One of the important characteristics of the remanufacturing industry is that its products have a much lower energy content than the same products made from virgin material. This was clearly shown in recent research by Professor Sutherland and his colleagues at the Michigan Technological University on the amount of energy required for various metallurgical operations, relative to that necessary for a remanufacturing process. In one aspect of their study, they examined the energy input for manufacturing several diesel engine components, comparing the energy input required for new components to the energy necessary for remanufactured components. The results are summarized in Table II.

What is clear is that the energy necessary to produce a remanufactured component is far less than that for a virgin component. Others have demonstrated this same result, indicating that as a rule, remanufactured products require much less energy to produce.

Table II. Energy Consumption for Various Diesel Engine Components (after Sutherland *et al.*)

Engine Component	Casting/Manufacturing (MJ)	Remanufacturing (MJ)	Energy Reduction (MJ)
Engine Block (cast iron)	9,970	600	9,370
Cylinder Head (cast iron)	4,445	1,110	3,335
Crankshaft (steel)	2,800	110	2,690
6 Connecting Rods (steel)	330	10	320
6 Pistons (steel)	555	20	535
<b>Total Energy:</b>	<b>18,100</b>	<b>1,850</b>	<b>16,250</b>
<i>1 MJ = 1 megajoule = 1 Million Joules, where a joule is a unit of energy</i>			

If we consider this energy input a measure of a product’s carbon content, or more commonly “carbon footprint”, then we can see remanufactured components have a much smaller carbon footprint than their virgin counterparts. Armed with this knowledge and the general concern over GHGs, can the Remanufacturing Industry capitalize on a market seeking smaller carbon footprints? As it turns out, a number of companies throughout the EU have begun labeling the carbon content of their products, with the idea that, given quality and performance factors being the same, savvy customers will choose products with a lower carbon footprint (even if they cost more). For example, Tesco, the large UK grocery store, is now carbon labeling several hundred of its branded products in order to influence their customers’ purchasing decisions. Walkers, an EU firm in the highly competitive snack-food business, has also started carbon labeling its products for the same reason.

Carbon labeling has extended beyond consumer products to the B2B realm, as demonstrated by Volvo On-Highway Trucks. Volvo, always a first adopter in corporate sustainability initiatives, is now providing customers (and more importantly, potential customers) an “Environmental Product Declaration”, or “EPD”. It works by customers first identifying the product they are

interested in purchasing. Then Volvo provides specific product information related to environmental impact during manufacturing, such as the amount of energy, water and solvents consumed, the total amount of CO<sub>2</sub> released. Volvo is betting that its customer-base, one already attuned to environmental sensitivity, will use this information as an essential part of its purchasing decision process.

At the same time, many companies now are reporting their own GHG emissions, carbon footprints and reduction efforts. Caterpillar, GE, DuPont, and many others currently publish a yearly Sustainability Report along with their Annual Report. Many of these reports discuss new low-carbon products, energy efficiency strategies, as well as the company's commitment to reduce GHGs over time. In other words, GHG reduction and carbon footprints have gone mainstream and are now viewed as important to the long-term growth of a company.

So with this burgeoning awareness of carbon footprints among the business community and the growing impact carbon footprints have on consumer choices, how can the Remanufacturing Industry take advantage of this momentum with its lower-energy intensive products? As many companies are beginning to take carbon content into its product choices, the Remanufacturing Industry is well positioned to provide its carbon content information to its customers as well. To see how this might work, let's go back to the data in Table II. The carbon content for components of a new diesel engine is 18,100 MJ. The carbon content for the same components made by remanufacturing is only 1,850 MJ, or 16,250 MJ less. If the energy required to produce both types of components came from a coal-fired power plant, then we can quickly determine the carbon content of each product.

If we wanted to communicate the carbon content of the six steel pistons, then we could highlight the energy and carbon content as shown in Table III. From a purchaser's perspective, this information is valuable but perhaps not all that user-friendly. By adopting carbon labeling conventions as seen in some other products, we can market the pistons with a much easier-to-read and recognizable labels. One potential concept is shown in Figure 3, which shows the product (a piston), its carbon content (4 kg CO<sub>2</sub>), and the carbon content of a conventionally

manufactured piston (111 kg CO<sub>2</sub>). Now the customer can readily identify the remanufactured product, the one with a much lower carbon content.

Table III. Carbon Content (in terms of amount of CO<sub>2</sub> emitted during manufacturing) of Diesel Engine Pistons (after Sutherland *et al.*)

Diesel Engine Component Type	Energy Consumed During Manufacturing (MJ)	CO <sub>2</sub> Emissions (Metric Tons)	CO <sub>2</sub> Emissions (Kg)
6 – New Steel Pistons	555	0.111	111
6 – Reman Steel Pistons	20	0.004	4

The conversion from energy to metric tons or kilograms of CO<sub>2</sub> was accomplished using the EPA’s GHG Calculator at <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>

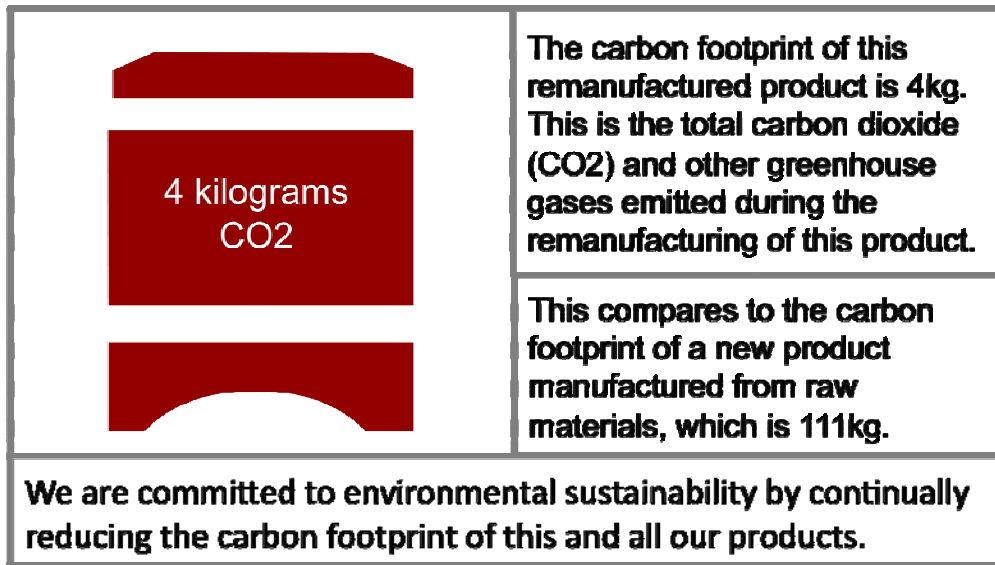


Figure 3. Possible Carbon Label for a Set of Remanufactured Pistons

Of course in order to be widely accepted and credible, the industry needs to adopt the appropriate protocols and standards on how carbon footprints are measured, and how they are compared and marketed. But considering the infancy of these initiatives, the industry can work in partnership to define these protocols, before they would be defined for them.

*Summary:*

Forward-thinking business leaders recognize a lower carbon footprint is a means to competitive advantage. They aggressively look for opportunities to reduce the energy content of their products and the energy consumption of their operations. As a result, these businesses are often rewarded with lower operating costs, top-line revenue growth, and greater profitability.

Considering the lower energy content of a remanufactured product, the Remanufacturing Industry has a tremendous opportunity to capitalize on this same advantage. By first recognizing the opportunity, engaging in carbon footprint analyses and then communicating this to their customer-base using a clear and understandable carbon-labeling approach, the Remanufacturing Industry can enhance their market position in the eyes of their stakeholders as more environmentally and financially sustainable enterprise for the long-term.

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### About the Author:

Dr. Michael Readey is President of Aeris Analytics LLC, an environmental services business focused on helping commercial customers economically reduce engine and greenhouse gas emissions. Aeris Analytics was formed in 2009 as a response to ever increasing emission regulations impacting commercial fleet owners. With Aeris Analytics, Dr. Readey brings his 20+ years of product development, regulatory and commercial management experience to help clients navigate through the environmental maze of regulatory, compliance and emissions technology options.

Michael is the author of several recent articles on greenhouse gases and emissions footprints. He also writes a blog on his website titled “The Emissions Café” where he informally discusses emissions and emissions technologies.

Before launching Aeris Analytics, Michael spent 13 years working for Caterpillar, one of the world’s largest diesel engine and earthmoving machine manufacturer. During this time he held several leadership positions as CAT’s Aftertreatment Product Manager, the Tier 4 Development Manager and CAT’s Emissions Retrofit Product Director.

Michael received his BS and MS in Engineering from Ohio State University, and his Ph.D. from Case Western Reserve University. Throughout his career he has contributed over 40 scientific publications, edited two books, and has given over 200 technical presentations around the world in the area of corporate sustainability, diesel engine emissions, aftertreatment and materials technology.

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*Aeris Analytics helps clients navigate through the emissions maze, reduce their financial risk of non-compliance, and enhance their competitiveness through more sustainable operations. For more information please contact Michael Readey at [mjreadey@AerisAnalytics.com](mailto:mjreadey@AerisAnalytics.com) or visit our website [www.AerisAnalytics.com](http://www.AerisAnalytics.com).*