The Fabrication Factor

BY GEOFF WEISENBERGER

The fabrication shop is important in determining not only the cost of a structural steel package, but its environmental impact as well.

WHEN IT COMES TO MEASURING the environmental footprint of structural steel, most of the focus tends to be on the steelmaking process. And depending on whose numbers you are looking at, the numbers can vary quite a bit.

In one of the more widely published categories—carbon footprint—we've seen numbers ranging from just over 0.5 tons of CO_2 per ton of structural steel produced to around 2.5 tons per ton. The variation in the numbers is a result of a wide range of assumptions in the collection of the data, such as domestic-versus-world averages, variations in the percentage of non-carbon-based electric production in different electric grids, calculation methodology, recycling rates, and market-basket approaches to production methods using electric arc or basic oxygen furnaces. Pending the submission of domestic producer data to the World Steel Association (worldsteel) database, AISC generally quotes a value of 0.73 tons of CO_2 per ton of structural steel produced based on reported EAF data. However, in a study recently completed for AISC comparing steel- and concrete-framed structures, a value of 0.875 tons of CO_2 per ton of structural steel was used based on the worldsteel database adjusted for U.S. production.

Of course, production is only one step in the structural steel supply chain. Certainly the environmental impact of mill production accounts for the majority of the environmental footprint of structural steel, but that does not mean that activities at the fabricator shop are insignificant. Much to the contrary, the efficiency of the fabricator contributes greatly to minimizing the overall environmental impact of structural steel. For many structures the fab shop may be the key factor in determining whether a structural steel or concrete framing system has a lower overall environmental impact.

Until recently, there wasn't accurate environmental data on the domestic structural steel fabrication process. However, AISC recently conducted a study that collected this information and quantified the impact the average fabrication shop has on the overall environmental impact of structural steel. The study was performed for AISC by structural engineering firm HDR Engineering and environmental consulting firm Five Winds International/PE Americas.

In order to determine the environmental impact in several different categories, we first had to determine the inputs and outputs of the average steel fabricator. We mailed an anonymous survey to all AISC member fabricators asking for numbers on the following:

- Steel received and fabricated
- Scrap generated
- Water consumption
- Electrical usage
- Waste disposal
- Fuel usage (natural gas, propane, and diesel)
- Welding/cutting supplies
- Chemicals (paints, lubricants, and cleaning agents)

For each input, total consumption for all sites considered was divided by total steel production of all sites considered, in order to provide an average use rate.

Once the usage data was consolidated, it was then used to evaluate the environmental impact of each of these inputs and outputs. The carbon footprint of the fabrication process is just one of several areas of impact that were determined:

- Global warming potential (kg CO_2 equivalent, the internationally recognized unit of measurement for this area): Measures the effect of greenhouse gases. Each GHG

*Geoff Weisenberger is AISC's director of industry sustainability. You can reach him at **weisenberger@aisc.org**. You can also find out more about steel and sustainability at **www.aisc.org/sustainability**.*

Hamilton Construction Co.

Using solar panels, like this 74.3-kW array on the roof of AISC member fabricator Hamilton Construction in Springfield, Ore.,is one tactic for reducing the non-renewable energy use, and subsequent environmental impact, of a steel fabrication shop.

has its own global warming potential, which indicates its heat-trapping ability relative to that of CO_2.

- Acidification potential (mol H+ equivalent): Measures emissions that cause acidifying effects to the environment.
- Eutrophication potential (kg nitrogen equivalent): Measures excessive nutrient inputs into water and land.
- Ozone depletion potential (kg CFC-11 equivalent): Measures the relative amount of degradation to the ozone layer that a material can cause relative to trichlorofluoromethane (R-11 or CFC-11) being fixed at an ODP of 1.0.
- Smog potential (kg nitrous oxide equivalent): Measures emissions of precursors that contribute to low-level smog.
- Non-renewable energy primary demand (megajoules): Measures total amount of primary energy associated with a product. (Total primary energy demand was also measured.)

The results in each category were clustered fairly tightly. Although extreme, inconsistent outliers were removed from the results pool, two marginal datasets were left in, one that generally had the highest impacts in each area and another that generally had the lowest. These "worst-case" and "best-case" examples were included to demonstrate the range of impact that the environmental performance of the steel fabricator can have on a project.

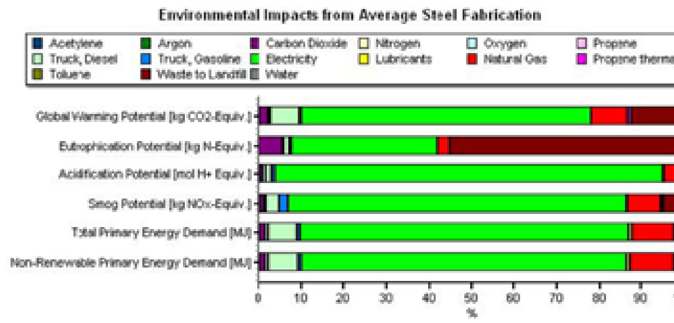
The study indicated that the average steel fabrication process contributes approximately 20% to the structural steel package's portion of a steel building's overall environmental impact—but we found that the high-impact fabricator can raise the impact by 10% to 33% and the low-impact fabricator can lower the impact by 6% to 14%, depending on the category. (Ozone depletion potential was excluded from further study as a result of the Montreal Protocol and the subsequent general worldwide elimination of ODP substances. Fabrication impact for ODP was in the range of 10^{-7} kg CFC-11 equivalents/kg of steel.)

Average Impacts of Fabricating a 1-kg Steel Part

	Average	Worst-case	Best-case
Global Warming Potential ($kg\ CO_2$-Equiv.)	0.215	0.261	0.193
Acidification Potential (mol H+ Equiv.)	0.0519	0.0595	0.0461
Eutrophication Potential (kg N-Equiv.)	4.54×10^{-05}	5.216×10^{-05}	4.04×10^{-05}
Smog Potential ($kg\ NO_x$-Equiv.)	3.37×10^{-07}	3.71×10^{-05}	3.16×10^{-05}
Non-Renewable Primary Energy Demand (MJ)	2.82	3.71	2.42

These data are not presented as an environmental claim on the part of the industry, as they have not been peer-reviewed as required under ISO standards relative to environmental claims. They are simply presented as the results of the subject study. AISC intends to continue collecting data relative to the environmental impacts of the entire cradle-to-cradle structural steel supply chain and when it is well documented, to submit those results for peer review.

While there are numerous activities that generate environmental impacts in a fabrication shop or any other operation, it's a good idea to examine those of greatest impact. So what were they? In every environmental category except for eutrophication potential, electrical usage was by far the biggest contributor. Natural gas and diesel fuel (used for shipping) were the next-largest contributors in most categories, but these barely approached that of electrical usage, which was 70%-80% of total environmental impact in most categories and even more than 30% in the eutrophication category. So clearly non-renewable electricity consumption is a good place to start for any fabrication shop looking to reduce its environmental impact. Electricity is consumed in nearly all fabrication operations, and improvements in equipment efficiency will dramatically reduce overall energy consumption. Installation of renewable power sources such as photovoltaic panels or on-site wind turbines will further reduce the consumption of fossil-based fuels, thus lowering the non-renewable primary energy demand, as will the movement away from fossil-fuel generation by electric utilities.



HDR Engineering/ Five Winds International/PE Americas

Electricity use, shown in green, accounts for a substantial majority of the environmental impact attributable to steel fabrication in five of the six categories considered in the study.

Another area highlighted by the survey where significant environmental gains can be made is in the amount of scrap generated by the fabrication process. According to the reported survey data, the average fabricator requires 1.2 tons of steel for every ton fabricated and shipped to the job site. You may be saying to yourself, "But steel scrap can be recycled!" Of course it can. But remember shipping that scrap back to a mill or recycling center not only requires fuel, but also the energy to melt the scrap and produce the new steel product.

So what does this mean for engineers who put a high priority on minimizing the environmental impact of their projects? Is there an easy way to determine whether one fabricator is more environmentally efficient than another? The majority of fabrication shops are clustered fairly tightly in almost every environmental impact category, and attempting to select a fabricator based on that criteria would be difficult. But that doesn't mean asking questions like "What is your energy usage per fabricated ton?" or "What are you doing to make your shop greener?" is a bad idea. Encouraging fabricators to improve their sustainable practices will help accomplish the structural steel industry's long-term commitment to reducing the environmental impact of structural steel—a commitment that has resulted in a reduction of 47% in carbon emissions and a 29% reduction in energy consumption at the mill level since 1990.

But the engineer can also play an active role in the reduction of the environmental impact of structural steel. Involving the fabricator early in the design process will allow an experienced fabricator to lend their expertise in terms of more efficient fabrication processes, bay sizing, and material selection. This will result in more efficient material management, less scrap produced, and lower electrical consumption. From there, the engineer and fabricator together can look into other energy-saving technologies or practices. MSC