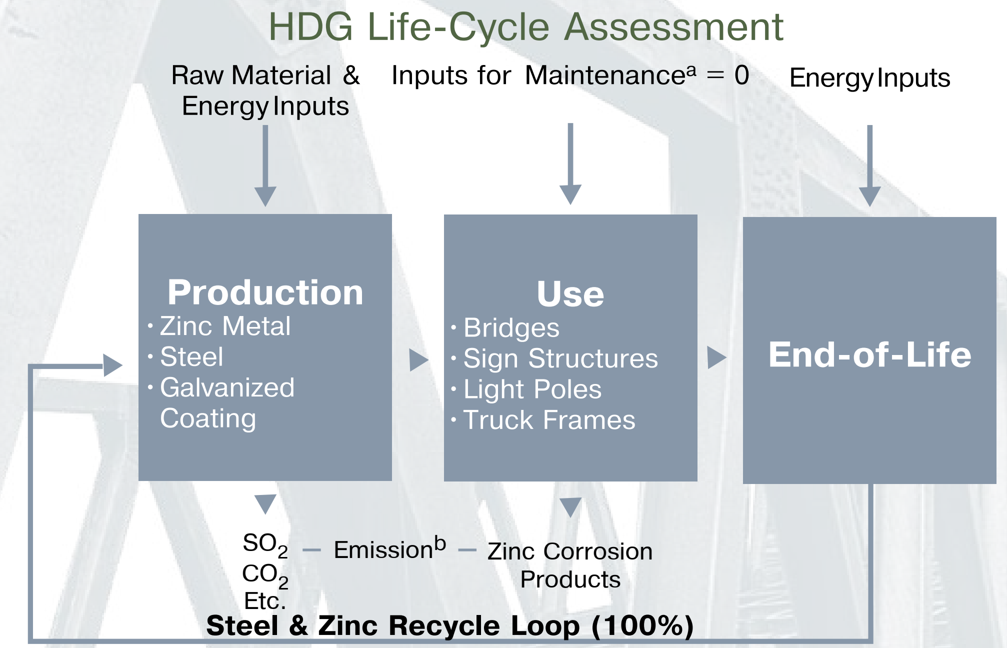
Hot-Dip Galvanized Steel is Green

Life-Cycle Assessment Supports Industry Claim

Life-cycle assessment (LCA) is the study of the environmental impact of a process or product, and includes measurement of energy consumed and all emissions during raw material production and manufacturing of the final product through use and end-of-life (recycling/disposal). An LCA is an accurate and empirical evaluation of how 'green' something really is.

Costs During Production Phase

Hot-dip galvanized (HDG) steel is created when zinc is metallurgically applied to steel to protect it from corrosion, levels of energy consumption and air/fluid/solid emissions were measured during zinc production from worldwide sources[1] and during the actual galvanizing process.[2] This data was combined with analogous survey data collected from the steel industry[3] and after well founded system boundaries and technical specifications were applied, internationally renowned LCA experts Five Winds International and PE International compiled an LCA (see *Figure 1*).



[a] For all but the most aggressive, corrosive environmental conditions, there are no energy or raw materials inputs during this phase of the life-cycle
[b] For hot-dip galvanized steel, naturally occuring zinc oxide, zinc hydroxide, and zinc carbonate

Figure 1

Hot-Dip Galvanizing Maximizes Taxpayers' Investment in America

- **Naturally occurring** metals & elements
- **Sustainable project** lasting 75 years or more
- **No maintenance** during the life of the project
- **No carbon footprint** during use
- **No emissions** after inital production
- **100% recyclability** at the end-of-life

Four important criteria were identified and the values for each during the production phase (steel, zinc, and HDG) are shown in the table below.

Production Phase	Primary Energy Use[a]	Global Warming Potential (GWP) (CO_2 equiv.)	Acidification Potential (AP) (SO_2 equiv.)	Photo Chemical Ozone Creation Potential (POCP) (ethene equiv.)
1 kg of HDG Steel	25.9 MJ	1.801 kg	0.00615 kg	0.000824 kg
[a] 10^6 Joules (unit of energy)				

[1] International Zinc Association, Brussels, Belgium, 2008
[2] Average from 13 N. American, European, S.African, & Australian galvanizing operations
[3] GaBi database

The energy consumption and environmental impact during the use and end-of-life phases are not as well understood and often not considered in the corrosion protection selection processes. To better understand the significance of those costs, a qualitative comparison of HDG steel to painted structural steel follows.

Costs During Use Phase

HDG steel requires no raw material or energy during the use phase whereas paint requires surface preparation and re-application, and the associated environmental cost P_1, P_2, P_3, and P_4, on a predetermined cycle ranging from every 12 to 20 years, as well as energy to transport labor and materials to the site. The following table provides the cost for HDG and identifies undetermined paint costs P_1, P_2, P_3, and P_4 during the use phase.

Use Phase	Primary Energy Use	Global Warming Potential (GWP) (CO_2 equiv.)	Acidification Potential (AP) (SO_2 equiv.)	Photo Chemical Ozone Creation Potential (POCP) (ethene equiv.)
1 kg of HDG Steel	0 MJ	0 kg	0 kg	0 kg
Painted Steel	P_1 MJ	P_2 kg	P_3 kg	P_4 kg

In addition, there are often significant indirect costs associated with paint maintenance such as exhaust from vehicles in traffic delays and particulate emission caused by surface-preparation blasting.

Costs During End-of-Life Phase

HDG steel at end-of-life is recycled into blocks/ingots of zinc and new structural steel. Because there is significant energy savings at the end-of-life, LCA credits HDG steel with 8.61 MJ for every kilogram recycled. The antithesis is paint which at end-of-life becomes a permanent part of the waste stream.

End of Life	Primary Energy Use
1 kg of HDG Steel[a]	-8.61 MJ

[a]Steel is the primary component and is 100% recyclable, however, the zinc in the galvanized coating is also 100% recyclable. Paint on the other hand, becomes a permanent part of the waste stream

Complete Life-Cycle Cost

Due to the LCA credit of 8.61 MJ/kg, resulting in a complete life-cycle primary energy use of 16.3 MJ, the complete life-cycle primary energy use for HDG steel is actually less than the primary energy used in the production phase. And as indicated above, because there are no emissions during the use and end-of-life phases for HDG steel, the initial environmental cost is the final environmental cost.

Complete Life-Cycle	Primary Energy Use[a]	Global Warming Potential (GWP) (CO_2 equiv.)	Acidification Potential (AP) (SO_2 equiv.)	Photo Chemical Ozone Creation Potential (POCP) (ethene equiv.)
1 kg of HDG Steel	17.3 MJ	1.801 kg	0.00615 kg	0.000824 kg

[a]Complete life-cycle energy use reflects production, use, and end-of-life credit

Summary

The durable corrosion protection of steel by coating it with naturally occurring zinc metal is unmatched in terms of its delivery of a safe, economical construction material requiring no maintenance for decades. Furthermore, because HDG steel is 100% recyclable, and requires no energy input and has no emissions during the use and end-of-life phases, hot-dip galvanizing is the most sustainable choice to protect our infrastructure from costly corrosion.