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Title: **By-Product Synergy: A Strategy for Sustainable Development**

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Abstract:

By-product synergy (also known as "green twinning," "industrial symbiosis," and "zero waste/zero emissions/100% product emissions") emphasizes the cooperation among diverse industries, agriculture, and communities that results in profitable conversion of by-products and wastes to resources promoting sustainability. This article examines the case study of Chaparral Steel Company of Midlothian, Texas.

By-Product Synergy:

A Strategy for Sustainable Development

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Sustainable development is most often defined as a way "to meet the needs of the present without compromising the ability of future generations to meet their own needs."[1] Recent efforts to promote this environmental, economic, and social approach-most notably the Clinton Administration initiative, the President's Council on Sustainable Development-have focused on strategies that will illuminate the relationship between sustainable development and commercial development. One such strategy is by-product synergy, which promotes joint commercial development of one economic sector with a related environmental sector. In practice, this means the waste product of one industry can be used by a second industry.[2]

Also known as "green twinning," "industrial symbiosis," and "zero waste/zero emissions/100% product emissions," by-product synergy emphasizes the cooperation among diverse industries, agriculture, and communities that results in profitable conversion of by-products and wastes to resources promoting sustainability. In 1995, the Business Council for Sustainable Development-Gulf of Mexico (BCSD-GM)[3] received a grant from the U.S. Environmental Protection Agency to identify examples of and opportunities for by-product synergy in industry, with the goal of helping U.S. industry export more eco-efficient technology.

The Practice of By-Product Synergy: A Case Study

Chaparral Steel Company is a noteworthy example of by-product synergy through zero waste/100 percent product steel making. This company, located in Midlothian, Texas, owns and operates a technologically advanced steel mill that produces bar and structural steel products by recycling scrap steel. Chaparral's production-which includes beams, reinforcing bars, channels, and merchant quality rounds-increased from 228,000 tons in 1976 to 1.6 million tons in 1995.

Chaparral is an established user of recycled materials. The company's primary source of scrap steel is old automobiles. To recycle this material, an automobile shredder facility, the largest and most productive in the world, is located next to the mill. In 1996, the shredder transformed more than 700,000 tons of old cars and other light scrap into raw material.

But what of the waste that results from the company's production process? EAF slag, mill scale, baghouse dust, auto shredder residue, nonferrous particulate, and spent refractories are all steel-making by-products. Chaparral has long sold mill scale to Portland cement producers to use as a source of iron oxide, and its success with this venture led the company to explore possibilities for recycling its other waste by-products.

Recognizing that these wastes were candidates for by-product synergy and other pollution prevention measures, Chaparral and Texas Industries, Inc. (TXI), a large cement producer that owns 84 percent of Chaparral, jointly initiated the "Systems and Technology for Advanced Recycling" (STAR) project to develop new synergies between the steel and cement manufacturing processes and the automobile shredding facility, all located in Midlothian. The goal "is to achieve

zero waste (for 100 percent product) . . . through better understanding of the process requirements and application of the innovative technology and sound economics."[4]

In the STAR project, Chaparral has successfully applied the principles of by-product synergy to its EAF slag by-product. In 1993, a joint team of Chaparral and TXI operating, technical, and management personnel collaborated in an effort to use Chapparal's slag by-product as a resource for TXI's cement production. The result was "CemStar," a patented process that adds slag to the cement raw material mix to yield larger batches of high-quality Type I Portland cement. This conversion process conserves natural resources while reducing energy requirements 10-15 percent. Furthermore, the value of the slag is increased 20 times, relative to its road construction value. By increasing production capacity 9 percent in FY1995, CemStar produced several million dollars of pretax income for TXI's two cement plants on an investment of less that $1 million. In addition, the CemStar process reduces overall carbon dioxide (CO_2) production from the cement-making process.

Next on the STAR project agenda: a new technology to achieve by-product synergy for the Chaparral automobile shredder residue. The shredder generates more than 180,000 tons of residue per year. In 1990, Chaparral installed a sophisticated Automobile Scrap Residue (ASR) cleaning system to reduce the amount of ASR that must be landfilled, and in 1996, after tests indicated that this ASR could be economically separated into essentially pure elements, the company purchased exclusive rights to an innovative flotation separation technology. This capability means that the nonchlorinated plastics residue may be used as a highly efficient and clean fuel source, rather than landfilled. In addition, the separation process will render aluminum, magnesium, and other residues so clean that the company hopes to attract more processing plants to Midlothian.

This technology may be applied not just to automobile scrap but to a variety of waste streams from many different processes. The economic benefits are substantial: in the case of Chaparral, the sale of nonferrous metals will pay for the plant in less than one year, and the sale of clean plastics will generate revenues of up to $500,000 per year. Chaparral plans to market this capability throughout North and South America.

After learning of Chaparral's success with by-product synergy, officials at the Texas Natural Resource Conservation Commission (TNRCC) offered to streamline the permitting process for the company's by-product synergy operations and help Chaparral identify potential applications for this technology.

Conclusions

The Chaparral experience provides a good example of the profitable conversion of by-products and wastes to resources. Such success requires creative collaboration between generators and consumers, which, in turn, can produce collaboration with government (as evidenced by the cooperation between Chaparral and the TNRCC).

The promise of by-product synergy as a strategy for sustainable development lies in its ability to raise profits while reducing pollution. Programs such as the one implemented at Chaparral have been cited as a strategy for achieving national goals for sustainable development by the President's Council, and the principles and practices of by-product synergy have been taught and researched at universities around the world.

Notes

1. The World Commission on Environment and Development (The Brundtland Commission), *Our Common Future*, Oxford Press, 1987.

2. U.S. Environmental Protection Agency, *Initiative on Commercial Diplomacy and Sustainable Development: Green Twinning*-3rd Draft, March 1995.

3. A nonprofit assembly of business leaders from the United States and Mexico, BCSD-GM was organized in 1993 to promote and implement cross-border, public-private partnerships that offer concrete, measurable ways to achieve sustainable development.

4. Libor F. Rostik, "Zero Waste Electric Arc Furnace Steel Making" (paper presented at the Waste Minimization/Pollution Prevention Conference, Philadelphia, Pennsylvania, June 1996).

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