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EXAMPLES OF BY-PRODUCT SYNERGIES

By-Product Synergy is a practical application of industrial ecology in which companies work together in a given region to match feedstock needs to by-products. Each regional project involves recruiting ten to twenty diverse companies as fee-paying participants and engaging local, state and federal government agencies as supporters. Through the BPS process, individual companies are transformed into a cross-industry team focused on turning every gram of material running through their plants into product.

CHAPARRAL STEEL

One of the earliest companies to adopt BPS was the Chaparral Steel Company. In the early 1990s, managers of Chaparral Steel began exploring synergies between the company's operations and the operations of its parent company, Texas Industries, a manufacturer of Portland cement. One of the most successful synergies discovered was the potential for steel slag to be used as a raw material for the cement. The steel slag contained dicalcium silicate (calcined lime), formed by the high temperatures of the steelmaking process and also a building block of Portland cement. By using the steel slag instead of purchased lime which would then have to be heated to calcination, Texas Industries reduced the energy requirements and related emissions (CO2, NOx, SO2) of the cement making process. Profits for both companies also increased.

The Chaparral Steel Company is an example of a number of companies successfully developing synergies. Other BPS studies, such as the Business Council for Sustainable Development projects—Tampico (Mexico), Alberta (Canada), North Texas, and Montreal (Canada)—have been larger, involving up to 20 companies and organizations that crosscut several industries. A sampling of successful synergy results are shown in Table 1.

As the numbers in the table indicate, BPS presents a large opportunity for reducing raw material consumption, energy use, and emissions and waste generation, along with the associated cost savings.

Table 1. Annual Cost and Environmental Benefits of Successful Synergies

Implemented Synergies	**Ecological/ Biological**	**Energy Savings**	**Residue Reduction**	**Cost Savings**
CemStar® 130,000 tons of steel slag used in place of lime (single plant operation)	Reduced SO2 (acid rain) through coal displacement	Displacement of 11,800 tons of coal used to calcine lime (3.5 billion Btu)	▪ 130,000 tons of steel slag not landfilled ▪ Emission reductions from coal displacement: 65,000 tons CO2, 800 tons of NOx, 33 tons of hydrocarbons	Steel producer: ▪ Value added to steel slag ▪ Reduced/eliminated steel slag treatment/disposal costs Cement producer: ▪ Less costly raw material ▪ Calcination is not required → energy consumption and associated emissions for cement production are reduced

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Implemented Synergies	Ecological/ Biological	Energy Savings	Residue Reduction	Cost Savings
Auto Shredder Residue (ASR) 120,000 tons of ASR mined for metal reclamation and ASR remaining after metal recovery used for power generation	Reduced SO2 (acid rain) through coal displacement	▪ 18,000 tons of metals (Al, Cu, Mg, Sn) recovered from ASR and not mined ▪ 98,000 tons of carbon-based ASR displaces 66,000 tons of coal for power generation (20 billion Btu)	▪ 120,000 tons of ASR not landfilled ▪ Energy savings associated with metal recovery vs. mining prevent 151,000 tons of CO2 emissions ▪ SO2 emissions reduced by substitution of ASR for coal	ASR producer: ▪ Reduction/elimination of ASR disposal fees ▪ Increased revenue from recovered metals ▪ Revenue from sale of ASR as alternative fuel ASR consumers: ▪ Lower cost, less energy intensive method of obtaining metals ▪ Lower cost fuel
Graphite/Copper Sludge 37,500 pounds of sludge saved from landfills and municipal water systems	Landfill not exposed to toxicity of copper waste	18,750 pounds of copper recovered and not mined (5.6 million Btu)	▪ 37,500 pounds of graphite/ copper sludge not landfilled ▪ 412,500 gallons of graphite/ copper tainted wastewater not released to municipal wastewater treatment	Sludge producer: ▪ Reduced/eliminated waste disposal fees ▪ Revenue from sale of sludge to copper extraction company Metal recovery company: ▪ Lower-cost source of copper

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The By-Product Synergy process was pioneered in the 1990s by the US Business Council for Sustainable Development (BCSD) and its BPS production unit, Applied Sustainability (AS). Projects were launched in the United States, Mexico and Canada during the past six years. The most recent projects are under way in the New Jersey, Gulf Coast and Kansas City regions. The US EPA has supported BPS for several years as a means of reducing air emissions and energy consumption and is formally partnered with the New Jersey project to explore regulatory flexibility options for environmentally beneficial synergies.

In each of these projects synergies emerged with potential for measurable financial, social and environmental values. Below are summaries of some of these collaborations.

TAMPICO

Beginning in October 1997, the BCSD-GM performed a by-product synergy demonstration project in Tampico, Mexico. Twenty-one companies participated, most from the petrochemical industry.

Participants:
Indelpro S.A. de C.V., G.E. Plastics, Grupo Primex, Policyd, Polioles, Pecten Poliesters, PPG, Dupont, Novaquim, NHUMO, INSA-Emulsion, INSA-Solucíon, Pemex, Petrocel-DMT, Petrocel-PTA, Sulfamex, Minera Autlan, Cryoinfra, Grupo Tampico, Johns Mansville, Enertek

Project Description:
The project produced thirteen potential by-product synergies that were pursued by participants, the most promising of which are listed here.

- ***PVC residuals:*** GRUPO PRIMEX converted PVC residuals into shoe soles.
- ***Acetonitrile***: PEMEX had 1,000 barrels of excess acetonitrile after one of its lines closed. Dupont saved money by substituting this acetonitrile for a more expensive solvent.
- ***CO2 recovery***: Four participants were emitting significant quantities of carbon dioxide. Consumers in the project area obtain CO2 from Cryoinfra's Mexico City plant, or from competitors. With local sources available, Cryoinfra planned to establish a CO2 manufacturing process.
- ***Rehabilitation of polymers with nitrogen:*** Cryoinfra conducted investigations into plastics recovery. Their process would use liquid nitrogen to pulverize oils, resins, and plastics that do not meet specifications, and homogenize the materials.
- ***Polymer residuals for materials of construction:*** Johns Manville focused on polymer residuals from GE-Plastics, PRIMEX, POLICYD and INDELPRO to determine whether they could be used to make construction materials.
- ***Polyethylene/polypropylene bags:*** Six companies were disposing of 134 tons of plastic packaging bags every year. GRUPO TAMPICO used them in the construction of platforms for ship loading.
- ***Gasification:*** PEMEX had a significant stream of waste hydrocarbons available as a fuel source. If municipal waste is used as an additional feedstock, a financially and environmentally sound waste-to-energy project might be developed.

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ALBERTA

In February 1999, AS initiated its first commercial BPS Project in Alberta, Canada involving sixteen corporate and research participants.

Participants:
Air Liquide, Petro-Canada, Alberta's Industrial Heartland Association, Shell Canada, Alberta Research Council, Suncor Energy Inc, Alberta Science and Research Authority, Syncrude Canada Ltd, Bovar TransAlta Corporation, Husky Oil, Trimac, Marsulex, Wascana Energy Inc

Project Description:
Alberta appeared to be an ideal backdrop for by-product synergy. Its economy thrives on its abundance of natural resources. The province has more than 60 percent of Canada's proven reserves of conventional crude oil, 85 percent of its natural gas, 63 percent of its coal, and all of its oil sands reserves. It has one of the world's most productive agricultural economies and its third largest primary economic sector is forestry. The challenge was to find ways of ensuring that this natural resource-based economy remains competitive and productive in an increasingly global economy.

The Applied Sustainability LLC project was championed by industrial leader Rick George, CEO of Suncor Inc., and was locally managed by Jim Leslie, President, IISD Business Trust, the corporation through which the International Institute for Sustainable Development (IISD) serves business and other clients. The project was led and managed by Applied Sustainability LLC, with assistance from Hatch Associates Limited and IISD.

Two important aspects of the Alberta situation emerged. First, the participants were relatively homogeneous – many had similar by-products. Secondly, Alberta's economy on a whole was largely extractive, with relatively low raw materials costs, which limits and creates significant competition for potential by-product synergies. Within the oil and gas sector, which was heavily represented in the project, it was evident that most of the "low-hanging fruit" had already been picked, and that the exploitation of new synergies would require a committed effort, and the involvement of new participants and business relationships.

During the BPS project, representatives of two facilities, a Weyerhaeuser Kraft mill and a Husky refinery, discovered that the spent caustic (NaOH with contaminants) from the refinery could potentially be used in the Kraft process to make up for Na losses. The idea was tested, negotiated and implemented in January 2000. The refinery trucks that were transporting spent caustic to injection sites began shipping the material to Weyerhaeuser's plant for reuse instead. The savings for the two companies was estimated at $300,000 per year plus significant operation and maintenance savings at Weyerhaeuser.

A total of 25 possible synergy opportunities were selected by the participants to pursue under five main classifications: energy, inorganics, sulphur and high-sulphur coke, industrial gases and eco-industrial parks. The project required the participating companies to rethink the notion of what constitutes waste, and what can, in fact, be reused. It made them aware of the benefits they achieve when they cooperate with surrounding industries and view themselves as part of a larger community.

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NORTH TEXAS

The synergy identification segment of the North Texas project began in July 1999 was completed in April 2000. Wes Taylor, president of TXU Power, championed the project.

Participants:
Air Products & Chemicals Inc, Trigen Energy Corporation, Gachman Metals & Recycling, Texas Industries, Inc, Mary Kay Cosmetics, TXU, Poco Graphite Inc, Vetrotex America, Texas Instruments

Project Description:
The participants explored a number of synergies during the first year of the synergy process including those highlighted below. The group plans to continue meeting on a quarterly basis through April 2004 to provide support to their synergy implementation efforts, and to continue to search for new synergy opportunities. Hatch Associates took over management of this project when AS was dissolved.

Wood scrap to Energy—TXU's wood waste from its tree trimming activities may form the base for a biomass-fueled electricity generation unit. Other wood scrap—including pallets, reels, etc.—may be included as well. The independent power producer that builds the unit will be able to sell the generated electricity to the Texas grid, and as a result, may be eligible for both tax credits and renewable energy generation credits.

Copper-laden Wastewater to Metal Recovery (implemented November 2000) – Poco Graphite has a by-product water resulting from coolant of its copper-impregnated graphite rods. The resulting wastewater is purchased by Gachman, who recovers the copper for sale in the market. The synergy will save Poco Graphite thousands of dollars per year and offer new revenues for Gachman.

Ammonium Hydroxide Replacing Sodium Hydroxide – Texas Instruments may be able to replace the use of their fresh sodium hydroxide with Vetrotex's by-product ammonium hydroxide. The current volumes of the latter are small, but are likely to increase. The next step is for Vetrotex to send a sample to TI.

Electrostatic Precipitator (EP) Dust as Fertilizer—the fiberglass manufacturer's EP dust has a high concentration of boron, a desirable component of dry fertilizer for land application.

Greater Value through Economies of Scale—the group is investigating whether they can receive greater value for their by-products (such as lab chemicals, pallets, drums, tires, electric equipment, etc.) if they pool their material streams.

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MONTREAL

The Montreal BPS project began in July 2000. Following eight months of intensive synergy-seeking, the group transitioned to meeting on a quarterly basis. They will continue to meet through July 2005 to provide support to their synergy implementation efforts, and to continue to search for new synergy opportunities.

Participants:
Abitibi Consolidated, Noranda - CCR, Shell Canada, Air Liquid Canada, Noranda – CEZinc, SNF EKA Chimie Canada, Noranda Corporation, Stablex, Ispat Sidbec, NOVA Pb, Trigen Energy Corp Nexfor, QIT-Fer et Titane, Tuyaux Wolverine

Project Description:
The participants explored a number of synergies:
Baghouse Dust – Nova PB, a lead smelter contracted Hatch Associates, Applied Sustainability's partner in the project, to conduct a feasibility study on processes to address hazardous baghouse dust. If the result proves feasible, Nova has indicated interest in building a $20 million process plant.

Hydrogen Effluent – One company has a relatively pure supply of hydrogen gas as a by-product. Several companies are interested in the gas as a fuel if it can be transported economically. A hydrogen peroxide facility could be possible as well.

Auto Shredder Fluff – High volume "fluff" from two auto shredder operations may provide competitive alternative fuel sources. Two steps to investigate are (1) the removal of low-energy components from one of the lower-purity streams, and (2) the compaction of the material to increase energy/volume ratio.

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NEW JERSEY PROJECT

The New Jersey project began in February 2002 and involves 15 facilities from the following companies. These companies represent a range of industries and processes which is key to expanding synergy opportunities.

Participants:
Burlington County Resource Recovery Complex, The Dow Chemical Company (3), Ferro Corporation, Hercules, Mannington Mills, Merck, Motiva Enterprises, NJ American Water, OTC-Burlington County, PSEG, Shield Alloy, US Pipe, Winziger Corporation

Project Description:
An important new element of the New Jersey project is the involvement of the U.S. Environmental Protection Agency (EPA). While EPA has been verbally supportive of by-product synergy in the past, its actions have been slowed by legal and operational barriers. The command and control structure of federal laws governing waste requires that materials are handled in a particular manner. Disposal rules are proscribed, and potential liability for non-compliance is set. Once a material is defined as a hazardous waste, for example, it is effectively locked into this regulatory system. This greatly reduces the potential for reuse.

EPA is using the New Jersey project as a pilot to understand the BPS process and to verify that by-product synergy benefits the environment. EPA is funding the Center for Clean Air Policy, a non-governmental organization, to select and analyze a representative sample of the synergies to determine their environmental impact versus current methods of handling and disposal. The results of these case studies can add to the credibility of BPS and give EPA a firm foundation upon which to promote its use.

The facilities have explored more than 50 synergies and are evaluating the characteristics of the waste streams to determine composition and day-to-day consistency of the composition. Approximately 12 of the synergies identified are being pursed by the various companies. Dow Chemical plants are pursuing the use of: 1) a latex emulsion stream (paint production), 2) off-grade or scraps of polyethylene, and 3) rigid polyurethane foam scraps.

The production of latexes used in paints generates a wastewater stream containing latex. Ultrafiltration is used to recover much of the polymer, but a small amount remains in the wastewater sent to a treatment plant. Also referred to as "white water" because the oil-based latex is insoluble in water, the latex adds a "stickiness." "Sticky" water can be used in road construction and in agricultural operations to control dust. The Public Service Enterprise Group (PSEG), an electric company participating in the NJ Project, has expressed interest in using the "sticky" water.

One of the Dow facilities has a polyethylene (PE) compounding plant that makes insulation and packeting for the wire cabling industry. PE that does not meet material specifications, as well as scraps, are currently landfilled, but Dow is looking to match the waste materials with a potential consumer. In the past, such material has been used in countries such as China to manufacture shoe soles. However, shipping costs can be expensive so the key to implementing this synergy is the identification of local customers.

The third promising synergy is the use of waste cuttings generated in the production of rigid polyurethane foam boards used as building insulation. Approximately 5% of the foam board is lost when cut down to size. The foam scraps can be shredded and added to potting soil to increase aeration.

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GULF COAST BY-PRODUCT SYNERGY PROJECT

The New Jersey project has acted as a trial run for Dow to become familiar with the BPS process and to gauge the success of BPS firsthand. Through the company's experience in the New Jersey project, Dow Chemical has recognized the potential cost savings and reduced environmental impacts of implementing by-product synergy. They will build on the results gained through the New Jersey project by sponsoring a Gulf Coast By-Product Synergy project.

The Gulf Coast project will consist of two phases carried out simultaneously: an internal Dow Chemical BPS project between the Texas Operations facility and other nearby facilities, and a traditional multi-company BPS project. The multi-company BPS project will involve 10-15 companies in a 100-mile radius of the Freeport/Houston area. Andrew Mangan, Executive Director of the U.S. Business Council for Sustainable Development, will lead the teams with support from cross-functional experts at the Dow Environmental Technology Center.

KANSAS CITY REGIONAL BY-PRODUCT SYNERGY PROJECT

In December 2002, the Mid-America Regional Council (MARC) in Kansas City asked Andrew Mangan of the US Business Council for Sustainable Development and the Elements consulting arm of BNIM Architects to determine the feasibility of launching a By-Product Synergy project in the Kansas City region. The project team is meeting with select private and public sector leaders in the community to determine potential project support. In June, the team will make its recommendations to MARC on whether to proceed with a full BPS project based on the support indicated