Dow Chemical Company: By-Product Synergy Process Provides Opportunities to Improve Resource Utilization, Conserve Energy, and Save Money

Benefits

- Identified potential annual cost savings of $15 million
- Found opportunities to reduce fuel use by 900,000 MMBtu per year
- Identified ways to decrease waste material production as much as 155 million pounds per year, turn the waste into useful products, and thus improve productivity, profitability, and community relations
- Found opportunities to reduce CO_2 emissions by 108 million pounds per year

Application

The By-Product Synergy process developed by the U.S. Business Council for Sustainable Development provides manufacturing facilities with opportunities to reduce pollution and save energy and money by working with other plants, companies, and communities to reuse and recycle wastes. The process brings clusters of facilities together to create closed-loop systems in which one facility's wastes become another's useful raw materials. These synergies reduce waste and promote the efficient use of natural resources.

Summary

Six Gulf Coast Dow Chemical Company manufacturing facilities participated in a study that focused on finding ways to reuse nonchlorinated wastes. The objective was to identify opportunities for waste reuse and for achieving greater synergy within Dow by crossing the boundaries between businesses, sites, and plants. This study—which is the first phase of a long-term, two-phase project—estimated that 155 million pounds per year of nonchlorinated waste by-products could be reused by implementing certain projects. The study also found that the energy savings potential could be 900,000 MMBtu per year. Dow is currently partnering with the U.S. Business Council for Sustainable Development to determine ways to implement the second phase of the project, which will involve identifying opportunities for synergy among various diverse companies and industries.

Public-Private Partnership

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) cosponsored the assessment. DOE promotes plant-wide energy-efficiency assessments that will lead to improvements in industrial energy efficiency, productivity, and global competitiveness, while reducing waste and environmental emissions. In this case, DOE contributed $100,000 of the total $205,000 assessment cost.

Plant Description

This project was a joint effort between Dow Chemical Company and the U.S. Business Council for Sustainable Development (US BCSD). Dow provides chemical, plastic, and agricultural products and services to a variety of consumer markets. The US BCSD is a nonprofit association of businesses whose purpose is to develop projects that demonstrate the business value of sustainable development. To do this, the US BCSD leverages industry resources with matching funds from government, foundations, and partner organizations.

Six major Dow manufacturing sites along the Gulf Coast participated in the study—four in Texas (Freeport, La Porte, Seadrift, and Texas City) and two in Louisiana (Plaquemine and St. Charles). Within the six sites, the study focused on 40 manufacturing plants representing various businesses that are supported by 14 business technology centers. The plants were identified as major generators of nonchlorinated waste; each plant produced more than 1 million pounds of waste per year. In this portion of the project, participants wanted to look for ways to reuse nonchlorinated wastes and to gain experience in using

US BCSD's By-Product Synergy (BPS) process effectively. The objective was to identify opportunities for synergy within Dow and among the 40 plants by crossing business, site, and plant boundaries. This was the first phase of a long-term, two-phase project; the second phase will identify synergy opportunities among other companies and industries.

Assessment Approach

The underlying concept of BPS is that everything in the Earth's natural ecosystem is used by some member of it, so nothing is wasted. Therefore, the BPS philosophy is to enhance the emergence of a diversified industrial ecosystem that relies on cooperation among the actors involved. In other words, industrial plants use each other's waste material and energy as resources to minimize the amount of virgin material and energy they consume as well as the waste and emissions they produce.

BPS brings neighboring industrial companies and organizations together to exchange basic information about their processes in order to identify potential synergies. The synergies can result in added revenues, new business opportunities, cost savings, and environmental and regulatory benefits to the industrial group as well as to the group's geographic region. The BPS methodology involves establishing a forum where engineers and experts in various processes explore reuse opportunities, collect information, and facilitate interactions among individuals, business units, and companies to identify the possibilities for reusing by-products.

In this study, the BPS methodology was combined with Dow's Six Sigma approach to decision-making. Six Sigma is a method that is intended to virtually eliminate the defects in a process. Dow's approach employs a series of steps described as define, measure, analyze, improve, and control. Here, the process began with a definition of the project's team, objectives, and participants. This was followed by the measurement stage, in which each plant's inflows and outflows were catalogued. The inflows and outflows were then analyzed for synergies by an experienced project team and in facilitated working sessions with project participants. In this way, participants discovered and defined various potential improvements that could emerge through cross-business linkages. They created action plans for synergies judged to be commercially viable, and they organized strategies for addressing technical, regulatory, and other barriers. Ideas for improvements were captured in standardized business plans that could be used to communicate and control implementation.

Results and Projects Identified

Projects identified during the first phase of the survey were divided into six categories. This section describes the potential project categories and briefly discusses each one.

Recover hydrocarbons and spent solvents—Several hydrocarbon and spent solvent streams were identified. Some are by-product compounds with chemical structures that are different from those of the desired intermediate products. The intermediate products are compounds that downstream customers could use in manufacturing other final products. Other by-products are waste solvents that have been used in manufacturing and are mixed with other compounds from the manufacturing process. Fifteen projects were identified in this category, and seven were recommended for implementation. The recommended projects cover seven types of hydrocarbon or solvent wastes that are mixtures of many compounds. An advanced separation technology could be used to extract a useful pure compound for use in other processes. Other applications might also be found that could make use of the particular physical or chemical characteristics of the by-product streams.

For example, if advanced separation technology could effectively separate ethyl acrylate and acrylic acid for reuse, incineration cost savings in combination with new revenue from recovered products could amount to as much as $3 million per year. However, capital and additional processing expenses would be needed. On the other hand, if new uses of the by-product as-is, or with little processing,

could be identified, savings could also be close to $3 million per year. In that case, there would be little or no need for a major capital expense.

Reuse sodium hydroxide by-product—Several million pounds per year of low-concentration (1%–5%) sodium hydroxide (NaOH) solution are generated in the plants that were studied. Currently, much of this material is neutralized with acid and then discarded. In one proposed project, a team could assess the feasibility of increasing the concentration of the dilute waste NaOH to make it more usable. In another project, they could assess the possibility of converting the soluble NaOH in the dilute aqueous stream into more usable insoluble salts.

A successful project to convert a weak alkalinity by-product stream to magnesium hydroxide could yield estimated cost savings between $640,000 and $1.6 million. These savings would result from being able to reduce the use of hydrogen chloride to neutralize NaOH for disposal. Because of the high pH of the by-product stream, the material is classified as hazardous waste under the Resource Conservation and Recovery Act, and its pH must be reduced before disposal. The project could thus convert a hazardous waste into a useful product.

Reuse sulfuric acid waste—Eight potential projects were identified, and three were recommended for implementation. Several different ideas were proposed that involve new on-site or external applications for medium-strength (~50%) sulfuric acid waste. Of the recommended projects, one involves assessing the potential use of sulfuric acid waste to control pH in the wastewater treatment unit, and another involves assessing the possibility of using the waste in another industry—for example, converting it to ammonium sulfate for use in manufacturing fertilizer.

Reuse Methocel waste—Highly concentrated Methocel[1] waste is currently incinerated. Synergy opportunities identified include (1) recovery of the crude cellulose ether and (2) making use of the physical and chemical properties that are attributes of the by-product to fulfill existing performance chemical needs and to create new applications.

Reuse ortho-toluenediamine (oTDA)—Ortho-toluenediamine (oTDA) is a relatively pure compound with no end-use customer. It is currently incinerated at a cost of hundreds of thousands of dollars per year. Synergy opportunities identified include (1) use the oTDA to manufacture polyols[2]; (2) sell it as raw material for use in manufacturing antioxidants, corrosion inhibitors, rubber chemicals, and dyes; and (3) make use of the physical and chemical properties that are attributes of the by-product to meet current performance chemical needs and to create new applications.

Reuse by-product hydrogen—The BPS project team discovered that some plants produce by-product hydrogen of various qualities, including "ultra-pure." They also discovered that other industrial plants buy pure hydrogen to use as a feedstock. The opportunity for synergy is to link plants that produce hydrogen as a by-product with those that can use it as feedstock.

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[1] Methocel cellulose ethers are water-soluble methylcellulose and hydroxypropyl methylcellulose polymers that bind, retain water, thicken, form films, lubricate, and much more. They add unique physical properties and performance to many products, including building materials, food, personal care products, and pharmaceuticals. Methocel is a trademark of Dow Chemical Company.

[2] Polyols are alcohols having many hydroxyl radicals, and they include polyethers, glycols, polyesters, and castor oil. Polyol, also known as polyhydric alcohol, is used as a reactant.

Projected Savings

The total amount of nonchlorinated waste by-products that could be reused by implementing these projects was estimated by the study team to be 155 million pounds per year. The total energy savings potential of the recommended by-product conversions was estimated to be 900,000 MMBtu per year. The equivalent reduction in carbon dioxide (CO_2) emissions would be 108 million pounds per year. The project team for the first phase of this work recommended focusing on synergy opportunities that do not require a significant capital investment. Potential annual cost savings were estimated to total $15 million.

Plant-Wide Assessments

Plant-wide assessments are one way to work with the U.S. Department of Energy's (DOE) Industrial Technology Program (ITP) Technology Delivery. Most plants can expect to save 10% to 15% of their annual energy costs by implementing the recommendations from an assessment.

Plants are generally selected through a competitive solicitation process. The maximum award is $100,000; equal or greater matching funds must be provided by the selected company. An industry-defined team typically conducts an on-site analysis of total energy use and identifies opportunities to save energy in process and utility operations, including motor, steam, compressed air, and process heating systems. The recommendations could include implementing emerging technologies that would be particularly effective in the plant's operations. These emerging technologies, although on the forefront of industrial manufacturing, are successful and commercially proven.

DOE encourages interested companies to submit proposals in response to a competitive solicitation for plant-wide assessments, usually offered once a year. Industrial plants that fall within ITP's initiatives are considered for an award. These include, but are not limited to, the agriculture, aluminum, chemicals, forest products, glass, metal casting, mining, petroleum, and steel industries. You can learn more about plant-wide assessments and solicitations on the Web at **www.eere.energy.gov/industry/bestpractices**.

BestPractices is part of the Industrial Technologies Program, and it supports the Industries of the Future strategy. This strategy helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and energy-management best practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

Project Partners

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