Sustainable U.S. Manufacturing: Chemicals and Allied Industries

Technology Area 5:

Waste Reduction and Recovery

Every year the Chemical and Allied industries generate and safely dispose of billions of tons of industrial processing waste. While the industry has made significant progress in recycling and reuse, these wastes illustrate a measure of lost productivity. Technologies and practices to reduce processing wastes result in improved energy efficiency, greater resource conservation, reduced environmental impact and reduced operating costs (lower raw material and disposal costs). Waste reduction also provides more freedom to operate by easing legal barriers and resistance to plant expansions and new plant construction. Additionally, the products produced by the Chemical and Allied industries create even greater quantities of downstream waste. Downstream waste can serve as potential raw materials and fuels; recovering this waste from downstream customers can provide low-cost domestic sources of raw materials and fuels for the Chemical and Allied industries and create new businesses and jobs in the collection and processing of these materials.

A. NATIONWIDE ADVANTAGES

- Innovative and sustainable recovery of waste materials reduces resource demands and environmental impacts
- Improves corporate citizenship within the community
- Sustainable and challenging scientific and engineering research to attract and engage our best minds

The benefits of internal and downstream waste reduction and recovery are obvious and considerable. The Chemical and Allied industries' efforts to reduce and recover their internal wastes have lowered costs and environmental footprints. Some gaseous, most solvent, and many solid wastes have useable fuel values. However, these "waste" fuels have greater value if the Chemical and Allied industries can recover products and reuse solvents. Additionally, industrial subsectors already recover, to some degree, waste from downstream and post-consumer material like paper, plastics and metals, providing insight into the advantages, and integrating the processes for their reuse. The Chemical and Allied industries know from these efforts that new research, development and demonstration (RD&D) work can achieve additional internal and downstream waste reduction and recovery that will benefit their companies, the nation and society.

B. NATIONWIDE SAVINGS, REVENUE, JOBS, & REDUCTION IN EMISSIONS

- Saving **170** trillion Btu/yr in natural gas - equivalent to the consumption of 4 million households
- Lowering greenhouse gas emissions by **31** million tons - equivalent to removing 6.1 million cars from U.S. roadways
- Providing revenue to potentially support **44,000** direct jobs
- Providing over $1.3 billion in corporate tax revenue

Serious technical challenges exist for internal waste reduction and recovery, which only increase when moving from solids, to liquids, to gases. *Reduction* in generated waste typically occurs via changes to manufacturing equipment and practices, which require substantial RD&D and long adoption times. *Recovery* of process waste provides the easiest, most near-term and largest opportunities for efficiency improvements. These waste streams already exist on the industrial site, and their recovery can capitalize on utilizing existing capital assets and knowledge. Recovery of downstream waste requires additional technological advances due to the further processing they have undergone, but in many cases existing capital assets can reuse the recovered material. The recovery of downstream waste also has other logistical, economic, and technological obstacles because of its relative novelty.

C. NATIONWIDE FISCAL REQUIREMENTS

- Federal investment of $140 million to initiate, augment and promote targeted RD&D partnerships
- Federal incentives and investments to expand RD&D-related postgraduate education and develop a highly skilled workforce

The needed RD&D advances focus on the following five areas:

1.) Gaseous Effluent Resource Recovery — Scrubbing, adsorption and thermal systems currently utilize gaseous effluents to remove unwanted contaminants prior to atmospheric discharge. The RD&D opportunities lie in recovering useful products or energy from these streams. A variety of technologies applicable to gaseous streams exist, including adsorption scrubbers (wet and dry using physical, chemical or biological phenomena), low-temperature separations (distillations and gas separation membranes) for product recovery, and reaction technologies (oxidation) for energy recovery. Additional RD&D process, scale and economic challenges arise when

applying these technologies more broadly because the valuable components (products or fuels) subsist at dilute concentrations in large volumetric streams. Bioreactors, biofilters and bioscrubbers demonstrate potential as they use organisms to process volatile emissions and have a more "earth-friendly" benefit than traditional treatment because the final disposed material can serve as commercial compost or mulch.

2.) Liquid Effluent Resource Recovery — Process water and solvents have a natural affinity to retain products and byproducts at very dilute concentrations. Concentrating the components of aqueous streams into useful/recovered products typically requires costly and energy-intensive separation and/or reprocessing technologies. Such recovery will require technologies capable of high selectivity and high flux, handling a wide variety of components, and equipment comprising robust materials to avoid fouling or corrosion. Depending on the type of separations and timing, reintegrating the recovered materials into the processes can increase yield and overall productivity. Separating the components out of aqueous streams makes recovered water more easily treatable and can make it usable again as input water. Furthermore, the sale or reuse of recovered products is more practical in concentrated form. Examples of the research needed in this area include: integration of reaction and separation systems such as reactive distillation, membrane reactors, and supercritical fluid systems.

3.) Solid Waste Resource Recovery — Typical solid waste like process sludge and residues, process consumables (e.g., filter media, adsorbents and catalysts), off-specification products and low value by-products vary greatly in their potential value and utility. The Chemical and Allied industries do well at recovering solid wastes on-site. However, RD&D can further optimize the value of these wastes and either recycle them on-site or convert the waste to a commercially useful material (i.e., input to another industry as fuel or raw material). On-site reuse lowers raw material costs and transportation costs and makes more-efficient and economic use of existing capital assets.

4.) Production Optimization — Optimizing or changing the process to generate less waste, as opposed to capturing and reusing the waste, will enhance sustainability. Achievement of operational optimization can occur through the implementation of equipment, and operational and control optimization technologies (e.g., variable speed drives, assessments for best practices identification and implementation and automated controls and data feedback). Process optimization, the most important method because of the large amounts and inherent high-value of waste streams in the Chemical and Allied industries, consists of multiple, dependent processing steps. Further research needs to identify new, more material- and energy-efficient replacement products, new chemical pathways, more efficient processing steps and cheaper, more effective catalysts, so that the overall processes will have a smaller waste footprint and/or more valuable byproducts as a result of the new waste stream configurations.

5.) Downstream Waste Recovery — Nearly all the non-consumable products from the Chemical and Allied industries have recovery potential via downstream recycling. This recycling targets manufacturers that take the raw or processed output from the Chemical and Allied industries to make finished consumer products. Recycling has long focused on paper, plastics and oils because the recovered waste often requires less energy to process into final product than other raw streams. The Chemical and Allied industries can take a similar approach and reprocess waste or scrap material from downstream manufacturers into new raw materials.

Immense challenges to downstream waste recovery undoubtedly remain. The technologies and processes for effectively collecting, sorting and processing the waste streams for many products requires comprehensive research in the areas of identification and sorting, operational and handling methods, and the chemical and pre-processing steps necessary to make the recycled waste viable for reuse.

This technology brief describes one of six areas in need of technological advances to support sustainable growth in the Chemical and Allied industries. These six areas require significant federal investment ($1.5 billion) in RD&D, and an increase in the number (>1,000) of chemistry and chemical engineering post-graduate degree workers. The potential commercial benefits include a 65% reduction in fossil fuel use, a 34% renewable resources mix in energy and feedstock supplies, and an industry-wide reduction in GHG emissions of 63%.

The ACS Presidential Roundtable on Sustainable Manufacturing brings together industrial, government, academic, and scientific and engineering organizations to enable sustainable manufacturing in the chemical and allied products industries. The Roundtable will provide a consistent source of credible, sound information on the application of principles of sustainability to chemical manufacturing industry stakeholders to influence public policy, standard setting organizations, and third parties directly relevant to the chemical enterprise. These briefs originated from the 2009 Vision 2020 Workshop. For more information on these six areas, and how focused investment can maintain the United States' position as the leader in global RD&D, visit: www.acs.org/smrt