Sustainable U.S. Manufacturing: Chemical and Allied Industries

Technology Area 1:
Alternative Feedstocks

Transitioning from petroleum and natural gas feedstocks to alternative, largely bio-based feedstocks is essential to the future sustainability of the Chemical and Allied industries. Creating new energy-efficient processes to utilize these bio-based and other feedstocks will allow the industries to produce goods from domestic resources with substantially lower carbon emissions. Vigorously pursuing this transition will allow the Chemical and Allied industries to achieve both important individual corporate sustainability goals and national greenhouse gas reduction goals without impacting the food and feed supply. The transition will create an entirely new manufacturing industry of feedstock supply, preparation and conversion, which will re-purpose idled or less-competitive manufacturing facilities and revitalize many local economies. Additionally, with chemical production and refining based on domestic raw materials, new domestic manufacturing plants and revitalized existing plants would not be susceptible to transition overseas – helping to maintain jobs, production and productivity in the United States.

A. NATIONWIDE ADVANTAGES

- Production of goods from renewable, diverse (e.g., forest-grown material, agricultural residue, purpose-grown algae, recycled carbon dioxide) and secure (domestic) resources.
- Creation of a new manufacturing sector and jobs in feedstock supply, preparation and conversion to carbon building blocks
- Attainment of unique global competitive advantage by utilizing our abundance of arable soils for feedstock production
- Transition of our economy's manufacturing and energy use toward a low-carbon future

The Chemical and Allied industries create products from over 63 million tons per year of carbon building blocks derived from petroleum (~83%) and natural gas (~17%). These feedstocks account for ~70% of the costs to produce plastics, synthetic rubber and fibers, fertilizers, and hydrogen. Developing biologically derived carbon building blocks (i.e., chemical precursors) to produce commodity chemicals offers an opportunity to replace petroleum and natural gas with renewable resources while lowering emissions. This transition will support job creation and provide new tax revenues.

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

- Sustainable replacement of **150** trillion Btu/yr natural gas - equivalent to the consumption of 3.4 million households
- Sustainable replacement of **130** million barrels of oil per year - equivalent to 13 days of all U.S. oil imports
- Lowering greenhouse gas emissions by **17** million tons - equivalent to removing 3.3 million cars from U.S. roadways
- Increasing revenue to support up to **70,000** direct jobs
- Providing **$2.1** billion per year in corporate tax revenue

Transitioning to alternative feedstocks requires more than simply changing raw materials. It entails developing new growing and harvesting techniques, supply and feedstock preparation infrastructure, and new chemical pathways and chemical processing technologies. The transition should focus on significant and new research, development and demonstration (RD&D) work, which will require substantial financial and intellectual investments. The extensive work and resources needed to achieve this transition will require robust partnerships between industry, academia and government. The nation's near- and long-term global competitiveness, achievement of sustainability goals, and reduction of fossil fuel demand greatly depends on our efficient use of resources.

C. NATIONWIDE FISCAL REQUIREMENTS

- Federal investment of $380 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

Innovation partnerships that augment and hasten the Chemical and Allied industries efforts will further accelerate alternative feedstock development and implementation. Progress in the following four (4) RD&D areas is essential:

1.) Renewable Feedstock Infrastructure — Entirely new growing, harvesting, transport, storage and preparation industries will need to develop regionally in order to reliably supply the Chemical and Allied industries with the scale of feedstock required to reach their sustainability goals. Harvested biomass must be converted into an appropriate form for use in subsequent processing steps. The ability to blend and process multiple regional biomass resources into useful and consistent feedstocks will drive the development of appropriate-scale infrastructure. Developing these preparation systems will require collaborative efforts between renewable feedstock owners

and suppliers, equipment suppliers, feedstock processors and the Chemical and Allied industries. Despite its importance to making biomass resources energy efficient, the preparation step is often overlooked. Technology developments and infrastructure must coincide with both developing renewable resource mixes and designing new chemical building blocks.

2.) New Chemical Conversion Pathways and Technologies — Compared to crude oil or natural gas, biomass has a more complex chemical structure, and contains more extraneous components (e.g., water, ash and nitrogen). These factors add considerable complexity to the economical and efficient conversion or refining of biomass chemical structures into useful chemical building blocks. To meet this challenge the Chemical and Allied industries must develop new biological and/or thermochemical conversion refining processes. RD&D is critical for economically converting renewable feedstocks into more useful components such as sugars, oligomers, alcohols and natural polymers (e.g., lignin). Utilizing these components will require new chemical pathways and technologies to manufacture the traditional products derived from oil or gas. Currently, most RD&D focuses on converting bio-feedstocks into transportation fuels. While important, fuel conversion will not advance the use of alternative feedstocks in producing the essential chemical products, like plastics, that we use every day. Hydrogen and biomass represent materials viable as both transportation fuels and as general feedstocks. The **MATERIALS FOR SUSTAINABLE MANUFACTURING** brief contains more information about the materials needed for hydrogen production and storage.

3.) Economic and Efficient Processing Technologies — Developing new chemical pathways and technologies must carefully balance the use of existing capital assets with the design of efficient new processes. The Chemical and Allied industries can utilize the asset base as a valuable resource to lower the barrier-to-entry costs and hasten the transition to renewable feedstocks when existing plants need only limited modifications.

Substantial RD&D will support the scale-down of commodity process technologies to make them economical and efficient and allow them to match available local biomass infrastructure. The resulting smaller plants will require efficient and more economical processing technologies in order to displace the older, existing asset base.

Coal, tar sands and oil shale, other possible alternative carbon resources, though obtainable at large scale and low cost, do not provide the obvious sustainability advantage of bio-based resources. Carbon dioxide (CO_2) – an inexpensive and renewable feedstock – could theoretically act as a possible starting candidate for chemical building blocks, but would require the development of transformational technologies for its economic capture and efficient conversion. Before RD&D work begins, detailed, scientifically based life-cycle assessments of the potential costs and benefits of fossil- and CO_2-based pathways requires further exploration.

4.) New Materials and Products — The Chemical and Allied industries need to develop innovative bio-based materials and products. The current slate of options includes corn waste, wood, grasses, grain and oilseeds, residues from food, feed and fiber crops, and secondary plant biomass like mill and food processing wastes, animal wastes and waste cooking oils. The main goals for developing biomass include improving energy density and the ease of harvesting, and identifying or improving biomass that can be processed into new and innovative final products. These goals must succeed while keeping the products and processes profitable, sustainable and environmentally benign.

The Chemical and Allied industries require comprehensive research in comparative production potentials, environmental impacts and life-cycle studies (e.g., effects upon water, nitrogen and carbon), effects on food safety and supply, weediness and invasiveness, as well as research into related topics like the processing and support technologies that convert the biomass into finished products.

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