Sustainable U.S. Manufacturing: Chemical and Allied Industries

Technology Area 2:
Energy Efficiency

More efficient energy use is the fastest, cleanest, and lowest cost step to sustainable manufacturing and to improving the global competitiveness of the Chemical and Allied industries. Increasing energy efficiency contributes to a wide range of national and societal benefits - improved energy security, conservation of energy resources, and decreased greenhouse gas (GHG) emissions. Improving global competitiveness preserves and creates jobs and increases economic activity and the standard of living. Many practical energy-efficient technologies and options currently exist, but fail to garner widespread implementation because of economic, site-specific and/or other perceived risks. That being said, newer energy-efficient technology and practice options continually emerge into commercial practice. Broader application combined with accelerating the deployment of emerging industrial energy-efficient technologies and practices will generate substantial benefits to the nation.

A. NATIONWIDE ADVANTAGES

- Sustainable energy efficient improvements to processes and facilities with corresponding costs and waste reduction
- Short development and implementation timelines yielding earlier competitive advantages
- Improved energy security, decreased GHG emissions
- Job preservation and creation
- Sustainable and challenging scientific and engineering research to attract and engage our best minds

A common perception exists that many easy-to-achieve energy efficiency improvements have reached exhaustion, leaving only difficult and/or lower economic return projects. In reality, industrial energy efficiency continues to upgrade thousands of technologies and practices. Accelerating technology development and implementation represents the real challenge to a more efficient use of energy. Significant additional benefits can occur when developers, industry users, academia and government collaborate to expand the scope, scale, and effectiveness of energy-efficient options. Even when these technologies and practices do not provide extraordinary changes in individual plant energy use, their widespread adoption produces substantial and tangible benefits at the industrial and national level.

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

- Saving **440** trillion Btu/yr in natural gas - equivalent to the consumption of 10 million households
- Saving **120** million barrels of oil per year - equivalent to 13 days of all U.S. oil imports
- Lowering greenhouse gas emissions by **78** million tons - equivalent to removing 15 million cars from U.S. roadways
- Providing revenue to potentially support **110,000** direct jobs
- Providing $**3.3** billion in corporate tax revenue

Improving and expanding the efficient use of energy requires a combination of research, development and demonstration (RD&D) of technologies and practices combined with the dissemination of evaluation tools. Evaluation tools not only increase awareness, but more important, they allow calculation of the situation-specific costs and benefits of energy-efficient improvements to support decision-making. The RD&D will require substantial investments of time and money and will include expanding the applicability of available energy-efficient technologies to new sectors and developing entirely new and inherently more efficient technologies and processes compared to current options.

C. NATIONWIDE FISCAL REQUIREMENTS

- Federal investment of $280 million to initiate, augment, and promote targeted RD&D partnerships
- Federal incentives and investments to expand RD&D-related postgraduate education and a highly skilled workforce

These developments require a constant flow of advanced and economical technologies, which only arise from sustained RD&D efforts. Major advances needed for improvements fall into the following four (4) RD&D areas:

1.) Low-temperature Heat Recovery — Numerically, low-temperature, waste-heat recovery represents one of the greatest opportunities for improving overall energy efficiency. Typically, most process exhaust gas streams employ heat-recovery technology, but limit recovery to ~300°F in order to avoid condensation, which leads to corrosion, fouling and erosion problems on heat exchange surfaces. Potential low-quality heat technologies include deep economizers, direct and indirect condensation recovery, transport membrane condensers, heat pumps, heat wheels and power generation options (e.g., Kalina cycle, organic Rankine cycle and thermoelectrics and piezoelectrics). RD&D plays a vital role in advancing waste heat recovery technologies into the lower temperature realms. This work must develop new materials that function in condensing environments, create designs that provide wider economies-of-scale, reduce retrofitting costs, and find advantageous uses for recovered energy.

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2.) Low-energy Separations — Separations technologies are some of the most widely used and energy-intensive processes in manufacturing. RD&D directed at low-energy, low-cost, flexible, more-easily maintainable separations technologies will improve competitiveness and sustainability. Expanded RD&D work can advance technologies, including: membranes, pervaporation systems, regenerable sorbents, ionic liquids systems and applications, liquid/liquid extraction chemistries, ion exchange, and crystallization technologies. RD&D in distillation, which accounts for most industrial separations energy, is needed to examine new multicolumn configurations, split columns, heat cascading, vapor compression and coupled separation/chemical synthesis columns. The potential savings in distillation could reach as high as ~263 trillion Btu/yr. Low-energy, low-cost separation could lead to air separations for oxygen enrichment or pure oxy-fuel combustion systems.

3.) Cogeneration — Reduction of emissions, a fundamental component of sustainability, with simultaneous production of useful thermal energy (e.g. steam) for production processes, makes cogeneration (also known as Combined Heat & Power, or CHP) a natural and proven method for improving overall energy efficiency. Both process and non-process applications use thermal energy in addition to electric power, and CHP/cogeneration produces both forms more efficiently and at lower cost than separate production. A cogeneration environment can also capture and utilize waste heat (see section 1). CHP systems need RD&D to lower the economic scale, provide advanced automated process integration, provide fuel switching capabilities, enable oxygen enrichment, enhance gas clean-up, prepare for carbon capture and improve turbine design and materials.

4.) Heat & Energy Management — Heat and energy management involves both process and non-process operations. Roughly 20% of energy use in U.S. manufacturing goes to non-process applications. The major non-process energy uses include facility heating, lighting, air conditioning, hot water, in-plant transportation, building systems and office equipment. Non-process energy use can be reduced by upgrading building equipment, installing controls and improving facility designs. RD&D can help adapt non-process energy-efficient technologies to the manufacturing environment.

Process heat and energy management will benefit from RD&D in computational controls, modeling, prediction and sensors. RD&D will allow for efficiently integrating electric utility and CHP systems with process parameters to optimize energy transmission, distribution, safety and storage to meet plant requirements. These systems will need to predict and accommodate intermittent solar, wind and other renewable supplies of energy. They will require developments in power switches, electronic circuit breakers, voltage support systems and transformers as well as materials developments in industrial-scale battery and capacitor technology.

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