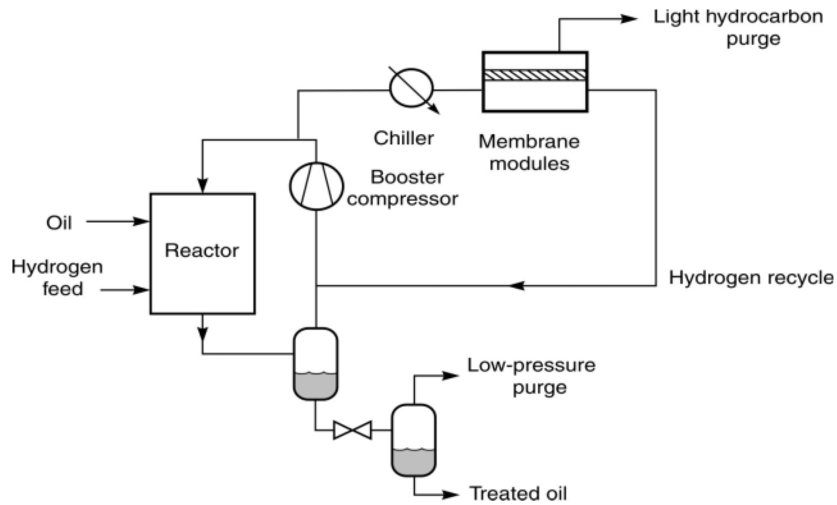
1.4.2 RESOURCE RECOVERY AND UTILIZATION

Technology Description

Resource recovery and utilization technologies help minimize waste from industrial processes, reducing energy and material requirements. Wastes include materials, process byproducts, chemical reactants, gases, solvents, diluents, wastepaper, plastics, cooling water, and more. These materials can be reprocessed for use as feedstocks, used to make different products, burned as fuels, or recycled. These practices mitigate greenhouse gas (GHG) emissions by improving plant efficiency and eliminating the energy required to treat wastes and to produce the displaced feedstocks. One example of recovery and reuse is a membrane separation process being developed to recover valuable chemicals from gas streams that are currently burned as low-value fuel. The process will efficiently and economically separate light hydrocarbons (ethane, methane, ethylene, propylene) and hydrogen for use as chemical feedstocks, which are two to three times more valuable than the fuel.



Recovery of olefins such as ethylene and propylene reduces the use of fuel and feedstocks.

System Concepts

- Resource recovery and utilization involves cradle-to-grave stewardship over industrial products. In the example cited, the recovery of feedstock chemicals mitigates CO_2 emissions because it increases product yield and displaces some of the fuel energy initially required to produce the feedstock, which is a petroleum fraction.
- The approximate 30 million tons of ironmaking and steelmaking byproducts generated each year – oxide dusts, sludges, scale, and slags – contain nearly 7 million tons of valuable iron units. Currently, about 50% of this volume is recovered and recycled. Research leading to increased internal recycling of these residues can increase the steel industry's primary yield while reducing disposal costs and saving energy.
- Resource recovery and utilization can involve advanced separations, new chemistries, improved catalysts, advanced materials, optimal process and engineering design, sensors and controls, post-consumer processing, market sensitivity, and close coordination among producers, users, and post-consumer processors.
- This pathway includes technologies that impact the other three industry technology pathways, particularly energy conversion and utilization and industrial process efficiency.

Representative Technologies

- Recovery technologies include advanced separations, new and improved chemistries, sensors and controls, capture of methane (coal beds, landfills, agricultural), and the capture of carbon monoxide and NO_x.
- Reuse technologies include recycling; new and improved chemistries; and closed-loop, sustainable plant design.
- Improved understanding of fundamental chemistry allows use of carbon dioxide and other recovered byproducts as feedstocks. Technologies include C1 chemistry (single carbon) to produce chemicals from carbon dioxide, and chemistries to create fuels from plastics and rubber.
- Component technologies include advanced separations, improved chemistry, improved catalysts, advanced materials, optimal process and engineering design, sensors and controls, and post-consumer

processing. An example of DOE-supported component technology is the recovery of thermoplastics via froth flotation, which enables the recycling of plastics from auto shredder waste.

Technology Status/Applications

- Many industries make a concerted effort to reuse wastes to minimize the high cost of handling and disposal. Others, like the refining and pulp-making industries, rely heavily on byproduct fuels produced on site. However, there are still many opportunities to reuse wastes and byproducts that are not captured because technology does not exist, is currently not economical, or is not practical for other reasons.

Current Research, Development, and Demonstration

RD&D Goals

- R&D goals target a range of improved recycling/recovery efficiencies. For example, in the chemicals industry the goal is to improve recyclability of materials by as much as 30%.
- Identify new and improved processes to use wastes or byproducts; improve separations to capture and recycle materials, byproducts, solvents, and process water; identify new markets for recovered materials, including ash and other residuals such as scrubber sludges.

RD&D Challenges

- Specifically target the energy-intensive U.S. industries and contribute to their goals of reducing energy, water use, and toxic and pollutant dispersion per unit of output.
- Enhance understanding of advanced computing; modeling capabilities for improved process and engineering design; and technology transfer.
- Develop efficient and economical separation processes; demonstrate the viability of new markets; improve sensing and control capabilities; analyze process and engineering design for optimized materials use; and develop durable advanced materials.

RD&D Activities

- Solicitations by the Industries of the Future program and the National Industrial Competitiveness Through Energy, Environment, and Economics program have funded projects to improve energy efficiency and reduce waste; participants include industry, DOE laboratories, small businesses, and academia.
- Ongoing activities include novel techniques for effective separation of materials in industrial streams for recovery and reuse, recycling of water and other liquid and solid-waste streams, recycling of wood byproducts and pulping waste into high-value products, and recycling of problematic wastes such as sludges, refractories, slag, and mill scale.
- DOE is working with CQ Inc. and other partners to improve energy recovery and reduce waste in coal processing. By adding a binding agent into the process, mills can improve the physical characteristics of the coal to create a more acceptable fuel, improve processing efficiency, and reduce environmental impact.

Recent Progress

- A new process has been developed to allow the recovery and reuse of caprolactam from waste carpet. Discarded nylon carpets are converted back to virgin-quality caprolactam and used to make new carpets, saving nearly 700,000 barrels of oil annually. The process also saves fuel energy and reduces the amount of carpet that winds up in landfills.
- Researchers have developed a process called froth flotation to cost-effectively separate thermoplastics of various densities without using hazardous chemicals. Recovering and separating various waste plastics can help industries reduce their costs for raw materials, and the process is environmentally sound as it reduces the amount of waste plastic sent to landfills.
- DOE supported development of an energy-efficient process employing pressure swing adsorption refrigeration (PSA) for the recovery of olefins from polyolefin plant vent gases. There already are two commercial applications of the PSA technology. Widespread commercialization could yield a recovery rate of more than 17 million pounds of olefins per year, as well as energy and emission reductions.

Commercialization and Deployment Activities
• Technologies that compete with resource recovery and utilization include waste disposal in landfills, incinerators, and approved hazardous waste-disposal sites. • The economics of resource recovery and utilization technologies are an important factor in deployment. Markets and applications for recovered materials must be well-defined if commercialization is to be successful. **Market Context** • Markets for recovered materials are as diverse as the manufacturing industry and the products it creates. Significant commercial success already has been achieved in various markets, such as the use of recovered post-use steel, aluminum, paper, glass, and plastic. Several new market opportunities are available in these – as well as other – areas and are just now being explored.