U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

INDUSTRIAL TECHNOLOGIES PROGRAM

Energy-Intensive Processes Portfolio:

Addressing Key Energy Challenges Across U.S. Industry

Contents

INTRODUCTION

The research and development (R&D) portfolio for Energy-Intensive Processes (EIP) addresses the top technology opportunities to save energy and reduce carbon emissions across the industrial sector. The portfolio focuses the expertise of industry, academia, and the National Laboratories on developing advanced technologies to radically increase the energy productivity of critical industrial processes and stimulate U.S. economic growth.

This brochure highlights the advanced industrial technology projects currently in the EIP portfolio. Through these projects, the U.S. Department of Energy's (DOE's) Industrial Technologies Program (ITP) seeks to eliminate entire manufacturing process steps or completely reinvent production pathways to significantly reduce energy use, carbon emissions, and material requirements. The brochure also includes four projects funded through the American Recovery and Reinvestment Act (ARRA) and some recently completed or nearly completed projects that address the key energy challenges of energy-intensive industries.

EIP supports multi-industry R&D in the following four platform areas:

- **Waste Energy Minimization and Recovery**
- **Industrial Reactions and Separations**
- **High-Temperature Processing**
- **Sustainable Manufacturing**

List of Energy-Intensive Processes Projects by Platform

Industrial Reactions and Separations

Crosscutting

Advanced Water Removal via Membrane Solvent Extraction

Enhanced Separation Efficiency in Olefin/Paraffin Distillation

High Surface Area Inorganic Membranes for Process Water Removal

Inorganic Membranes for Refinery Gas Separations

Process Intensification with Integrated Water-Gas-Shift Membrane Reactor*

Robust Polymer Composite Membranes for Hydrogen Separation*

Industry Specific

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New Design Methods and Algorithms for Highly Energy-Efficient and Low-Cost Multicomponent Distillation (Chemicals Industry)

Hydrogen Transport Membrane for Ethylene Production (Chemicals Industry)

Heat-Integrated Reactive Distillation Process (Chemicals Industry)

Purification of Biofuels and Biochemicals Using an Advanced Polymeric Membrane System (Chemicals Industry)

High-Temperature Processing

Crosscutting

High Magnetic Field Processing—A Heat-Free Heat-Treating Method

Energy-Efficient Thermomagnetic and Induction Hardening

Ultra-Fast Boriding in High-Temperature Materials Processing Industries

Ultra-High-Efficiency Aluminum Production Cells*

Industry Specific

Rapid Conditioning for Next-Generation Melting (Glass Industry)

Energy Saving Melting and Revert Reduction Technology (Metal Casting Industry)

Minimization of Blast Furnace Fuel Rate by Optimizing Burden and Gas Distribution (Steel Industry)

Paired Straight Hearth Furnace—Transformational Ironmaking Process (Steel Industry)

Isothermal Melting (Aluminum Industry)

Waste Heat Minimization and Recovery

Crosscutting

Improved Heat Recovery in Biomass-Fired Boilers*

Modifications and Optimization of the Organic Rankine Cycle

Advanced Combustion Diagnostics and Control for Furnaces, Fired Heaters and Boilers

Industry Specific

Thermochemical-Recuperation for High-Temperature Furnaces in the Steel Industry (Steel Industry)

Sustainable Manufacturing

Crosscutting

Electrohydraulic Forming of Near Net Shape Automotive Panels

Flexible Hybrid Friction Stir Joining Technology

Induction Consolidation and Molding of Thermoplastic Composites Using Smart Susceptors

Near Net Shape Manufacturing of New Titanium Powders for Industry

Ultra-Efficient and Power-Dense Electric Motors

Industry Specific

Highly Energy-Efficient Directed Green Liquor Utilization Pulping (Forest Products Industry)

Hot Rolling Scrap Reduction through Edge Cracking and Surface Defects Control (Aluminum Industry)

Renewable Microbial Polyesters for Cost-Effective and Energy-Efficient Wood-Plastic Composites (Forest Products Industry)

Screenable Wax Coatings and Water-Based Pressure Sensitive Adhesives (Forest Products Industry)

Wireless Monitoring of Steel Production Facilities (Steel Industry)

* Funded through the American Recovery and Reinvestment Act

INDUSTRIAL REACTIONS AND SEPARATIONS

Industrial reaction and separation projects target the development of advanced technologies to reduce energy consumption in energy-intensive conversion and separation processes, such as advanced water removal, gas separations, and hybrid distillation. Investments in these projects can reduce energy intensity in nearly all process industries throughout the manufacturing chain.

Advanced Water Removal via Membrane Solvent Extraction

Membrane solvent extraction (MSE) technology is being developed to augment distillation throughput in bioethanol production while decreasing energy and water consumption. This technology extracts ethanol from fermentation broth into an extraction solvent before separation in a hybrid distillation process. The MSE process reduces the thermal heat loads and the cooling loads by separating the majority of the water from the pure ethanol product at fermentation temperatures and reusing the waste energy streams available within the plant. The technology has the potential to reduce the cooling water use by 20% and energy use by 40%, in addition to water and energy savings and increased fermentation rates.

Project Partners

3M Company
St. Paul, MN

Archer Daniels Midland Company
Decatur, IL

Enhanced Separation Efficiency in Olefin/Paraffin Distillation

A new hollow fiber technology is intended to transform conventional separations in distillation processes that are used in petroleum refining and chemicals manufacturing. Replacing the conventional packing materials used in distillation columns for olefin/paraffin separations with hollow fibers has the potential to increase separation efficiency by 10%, which can help refineries decrease operating costs, reduce heating costs, and expand U.S. refining capacity. This development has the potential to benefit separation of light hydrocarbons in the petroleum industry and various chemical manufacturing operations, including vacuum distillation and industrial gas separations.

Project Partners

Los Alamos National Laboratory
Los Alamos, NM

Chevron Global Downstream, LLC
Richmond, CA

Morrison Consulting, Inc.
El Rito, NM

Spectrum Laboratories, Inc.
Rancho Dominguez, CA

High Surface Area Inorganic Membrane for Process Water Removal

Mini-channel planar membrane modules are being evaluated to improve water removal processes in ethanol fuel production, with potential for future application in natural gas dehydration and other distillation and extraction processes. The transformational ceramic/metallic hybrid membrane technology will have a surface area packing density one order of magnitude higher than conventional membrane tubes. Zeolite membranes and porous metallic substrate materials have the potential to use 20% less energy than conventional water removal processes to remove water or moisture from a range of industrial process streams.

Project Partners

Pacific Northwest National Laboratory
Richland, WA

University of California at Riverside
Riverside, CA

ADMA Products, Inc.
Hudson, OH

Pacific Ethanol, Inc.
Portland, OR

Inorganic Membranes for Refinery Gas Separations

This project is developing a hydrogen-selective inorganic membrane capable of operating at intermediate temperatures and under high pressure to transform conventional methods used to improve hydrotreating efficiency. Traditional approaches do not recover and recycle the unused hydrogen (H_2) resources, which is problematic because most refineries currently operate under H_2-starved conditions. However, this membrane—which is tailored specifically for refinery applications (i.e., is resistant to swelling and able to sustain extremely high pressures)—enhances the H_2 partial pressure in the reactor. An in-situ H_2 recovery and recycling process within the hydrotreating environment allows U.S. refineries to use lower quality crudes and enhances their ability to meet new ultra-low sulfur diesel requirements. This technology reduces the H_2 used in hydrotreating by 43%, which helps save energy by decreasing the need for H_2 production, an energy-intensive process that typically takes place at 900°C.

Project Partners

Media and Process Technology, Inc.
Pittsburgh, PA

University of Southern California
Los Angeles, CA

Chevron Energy Technology Company
Richmond, CA

Process Intensification with Integrated Water-Gas-Shift Membrane Reactor

This project seeks to develop hydrogen-selective membranes for an innovative gas separation process based on a water-gas-shift membrane reactor (WGS-MR) for the production of high-pressure hydrogen. Unlike lower-pressure hydrogen produced by other WGS-MR concepts, a high-pressure hydrogen stream can be used directly to produce chemicals such as ammonia and methanol; combusted for carbon dioxide (CO_2)-free power generation; or further filtered to create high-purity hydrogen. Replacing a conventional WGS reactor and CO_2 removal system with a WGS-MR and downsized CO_2 removal unit has the potential to reduce energy use during the separation process by up to 26%—or 14% of total plant energy use. This technology benefits industries that produce hydrogen from synthesis gas (syngas), including chemicals production, petroleum refining, metal manufacturing, and power generation.

Project Partners

Idaho National Laboratory .
Idaho Falls, ID

General Electric Company
GE Global Research
Niskayuna, NY

Western Research Institute
Laramie, WY

Robust Polymer Composite Membranes for Hydrogen Separation

Energy-efficient separation of hydrogen (H_2) from carbon dioxide (CO_2) in synthesis gas (syngas) is a critical step in power, fuels, and chemical production applications. A polymer composite membrane technology for H_2 separation from syngas is under development. Polymer design strategies that enable manipulation and control of free volume, chemistry, and morphology in high-temperature thermoplastics are being implemented. Membranes based on those design strategies will be fabricated and evaluated for their capacity to achieve the critical combination of high-permselectivity and chemical, mechanical, and thermal stability in the target harsh process environments. Compared to current state-of-the-art separations technologies, this approach lowers energy consumption by up to 70% in integrated gasification combined cycle power plants, reduces maintenance requirements, reduces CO_2 emissions, and increases separation selectivity in its application to syngas-to-fuels, syngas-to-chemicals, and syngas-to-power production processes.

Project Partners

Los Alamos National Laboratory
Los Alamos, NM

PBI Performance Products, Inc.
Charlotte, NC

University of South Carolina
Columbia, SC

University of Kansas City-Missouri
Kansas City, MO

Ammonia Production Using Pressure Swing Adsorption

Pressure swing adsorption (PSA) technology enables the energy-efficient recovery of ammonia from the product gas and purification of process reactants—nitrogen (from air) and hydrogen (from steam methane reforming). This new option eliminates the need for refrigeration and condensation systems, enables on-demand ammonia production, reduces waste, and reduces the need for on-site storage of hazardous combustibles. PSA provides a safer alternative to conventional ammonia production processes and allows for 100% recovery of ammonia, which reduces fuel and steam use, raw material needs, capital costs, and environmental emissions.

Project Partners

SmartKoncept Technology
Houston, TX

American Electric Power
Columbus, OH

University of South Carolina
Columbia, SC

TXU Energy Company, LLC
Dallas, TX

Agrium U.S. Inc.
Borger, TX

Distillation Column Flooding Predictor

The flooding predictor uses a patented pattern recognition system to identify the onset of flood and pre-flood conditions in distillation and separation columns. Distillation is a low-efficiency operation that consumes large amounts of energy. The flooding predictor allows petroleum refineries to operate columns nearer their true hydraulic limit, increasing throughput and energy efficiency by 10%. In addition, the ability to predict and avoid flood conditions is intended to decrease downtime, and reduce operating and maintenance costs.

Project Partners

2ndpoint LLC
Schererville, IN

The University of Texas at Austin, Center for Energy and Environmental Resources
Austin, TX

Fisher-Rosemount
Austin, TX

Shell Global Solutions
Houston, TX

Advanced Distillation—Heat-Integrated Distillation Using Microchannel Technology

Microchannel process technology (MPT) increases the typical thermal efficiency of current distillation processes by using heat exchangers to improve heat transfer at multiple stages. MPT is being designed and developed for advanced distillation, creating precise heat loads tailored toward individual distillation stage requirements in ethylene plants. Integrating heat transfer and separation into a single device eliminates the need for external heat exchange equipment (reboilers/condensers), reduces the size of distillation equipment, and decreases separation costs. When utilized in ethylene plants, this technology can result in energy savings as high as 20%.

Project Partners

Velocys, Inc.
Plain City, OH

ABB Lummus Global
Bloomfield, NJ

Development of Highly Selective Oxidation Catalysts by Atomic Layer Deposition

This project seeks to develop new techniques to manufacture catalysts by atomic layer deposition (ALD) for the selective oxidative dehydrogenation of alkanes (e.g., ethane to ethylene, propane to propylene, and butane to butadiene). Manufacturing techniques will be demonstrated by developing, characterizing, testing, and evaluating new catalysts for the selective oxidative dehydrogenation of alkanes on existing substrates in conventional reactors and in single-pass reactors utilizing anodic aluminum oxide ALD catalytic membranes. Improved catalyst uniformity and dispersion can allow for 5% higher alkene yields.

Project Partners

Argonne National Laboratory
Argonne, IL

INEOS Technologies, LLC
Naperville, IL

Northwestern University
Evanston, IL

Microchannel Reactor System for Catalytic Hydrogenation

New microchannel reactors are being designed and optimized to improve the efficiency of catalytic hydrogenation processes. Compared to conventional technologies, microchannel reactors promise a safer alternative to enhancing heat- and mass-transfer rates to improve yields. A laboratory-scale microchannel reactor/heat-exchanger system with thin-film or particulate catalysts for hydrogenation is being evaluated under moderate temperature and pressure. This reactor design is meant to reduce electrical energy use by 90%, steam use by 70%, and feedstock requirements by 10%, while generating 70% less waste in hydrogenation reactions. Improving hydrogenation reactions will benefit several operations in the chemical and pharmaceutical industries.

Project Partners

Stevens Institute of Technology
Hoboken, NJ

Bristol-Myers Squibb
New Brunswick, NJ

ChemProcess Technologies, LLC
Bensalem, PA

New Jersey Nanotechnology Consortium
Murray Hill, NJ

Information by Design
Hoboken, NJ

Frank Shinneman
New York, NY

New Design Methods and Algorithms for Highly Energy-Efficient and Low-Cost Multi-Component Distillation

Design methods and algorithms for low-energy distillation configurations can reduce energy consumption at chemical and petrochemical plants. Methods and software tools are being developed to enable the identification and analysis of optimal multi-component distillation configurations. These improvements can result in economically attractive configurations that retain the same number of distillation columns without additional reboilers or condensers, and reduce energy consumption by up to 40%. This research will ultimately allow a process engineer to easily screen and identify an optimal distillation column array for any given application.

Project Partners

Purdue University
West Lafayette, IN

Eastman Chemical Company
Kingsport, TN

University of Illinois at Chicago
Chicago, IL

Hydrogen Transport Membrane Technology for Ethylene Production

A hydrogen transport membrane reactor is being developed to produce ethylene via ethylene dehydrogenation. A ceramic metal composite membrane removes hydrogen from a dehydrogenation reactor, creating an equilibrium shift that leads to the production of ethylene, an approach that can achieve yields currently unattainable at lower temperatures. The process also reduces purification steps that represent about 50% of the energy consumption and 70% of the cost in the energy-intensive pyrolysis approaches used today, which results in energy savings of about 50%. The membrane process also prevents carbon-containing species from contacting air or steam, which completely eliminates the production of greenhouse gases.

Project Partners

Argonne National Laboratory
Argonne, IL

Psage Research, LLC
Macungie, PA

Heat-Integrated Reactive Distillation

Reactive distillation is an effective but challenging technique for energy-efficient industrial synthesis and separation processes that could be adapted to several petroleum refining and chemicals manufacturing applications and improve their energy efficiency by as much as 40%. To overcome barriers that prevent the widespread application of reactive distillation, this effort is developing catalytic contact-time methods and thermal management systems to improve the separation of products as they are formed at each equilibrium stage. Researchers are down-selecting the most promising applications and designing and testing a system to evaluate the technical and economic viability of the new process.

Project Partners

Argonne National Laboratory
Argonne, IL

ChemProcess Technologies, LLC
League City, TX

Purification of Biofuels and Biochemicals Using an Advanced Polymeric Membrane System

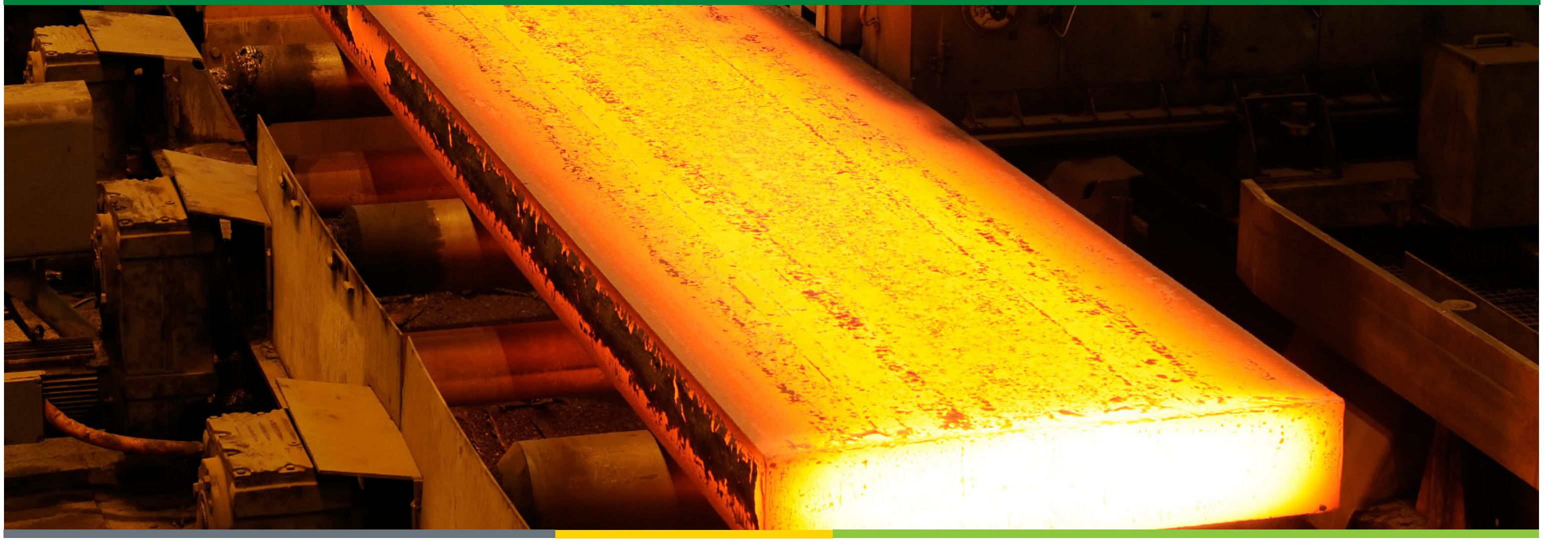
New polynorbornene-based pervaporation membrane cartridges are being developed for the production of chemicals and fuels made by biological means, such as fermentation. The new membranes enable the energy efficient removal of wanted organic products from dilute aqueous solutions, eliminating the energy and costs associated with conventional water evaporation processes. This research effort will specify the materials and manufacturing procedures required to make optimal membrane cartridges, provide process performance data, and identify and how best to integrate the membranes into a full-scale bio-butanol process. Ultimately, the membranes are expected to reduce the cost of biochemical and biofuel production by as much as 40%, improving their competitiveness against petroleum-based chemicals and fuels.

Project Partners

Los Alamos National Laboratory
Los Alamos, NM

Promerus, LLC
Brecksville, OH

SRI International
Menlo Park, CA



HIGH-TEMPERATURE PROCESSING

High-temperature processing projects target the development of lower-energy alternatives to conventional high-temperature processes that alter the physical and chemical properties of materials to achieve product specifications.

High Magnetic Field Processing—A Heat-Free Heat-Treating Method

An innovative non-thermal materials processing technology can overcome the energy-intensive steps involved in conventional heat treating to improve materials performance. Researchers are developing a high magnetic field processing (HMFP) heat-free technology to reduce or eliminate the need for cryogenic cooling or double-temper heat treatments for selected heat-treatment operations. The technology employs superconducting magnets that manipulate the materials' structures at an atomistic level, allowing producers to tailor structures at microscales and nanoscales while increasing production speed and quality. HMFP seeks to reduce thermal processing times from 1,200 minutes for conventional tempering to 5 minutes, and will benefit forging, casting, rod and bar, and sheet metal products as well as the manufacturing of specific components.

Project Partners

Oak Ridge National Laboratory
Oak Ridge, TN

Ajax TOCCO Magnethermic Corporation Development & Support Center
Madison Heights, MI

American Magnetics, Inc.
Oak Ridge, TN

American Safety Razor Company
Knoxville, TN

Carpenter Technology Corporation
Reading, PA

Caterpillar, Inc.
Peoria, IL

Dura-Bar
Woodstock, IL

Energy-Efficient Thermomagnetic and Induction Hardening

Hybrid induction hardening and thermomagnetic processing (ITMP) technology provides an alternative to conventional heat treatment processes. Researchers are hybridizing thermomagnetic processing with inductive high-frequency heat treatment to reduce costs and to reduce the amount of energy needed to induce the required component properties; ITMP aims to improve process yield and reduce the reworking of metals suitable for reprocessing. Using ITMP to treat forming dies can extend their lifetime and enable precision net shape forging in applications where cost had been prohibitive. This precise method can be 30% more energy efficient than conventional heat treatment and post-processing methods and would be applicable to nearly all ferrous materials that undergo industrial heat treatment processes, including those used in automotive, aerospace, and hydraulics applications.

Project Partners

Eaton Corporation
Southfield, MI

Ohio State University
Columbus, OH

American Magnetics, Inc.
Oak Ridge, TN

Oak Ridge National Laboratory
Oak Ridge, TN

Ajax TOCCO, Inc.
Warren, OH

Northwestern University
Evanston, IL

Multisolutions, Inc.
Oak Ridge, TN

Dura-Bar
Woodstock, IL

Ultra-Fast Boriding in High-Temperature Materials Processing Industries

Ultra-fast boriding is a transformational technology that can reduce the energy intensity of surface treatment processes employed today. Researchers are further developing, optimizing, and scaling-up ultra-fast boriding for high-temperature materials processing to displace or complement conventional boriding, nitriding, and carburizing surface treatment processes. The new surface treatment process is ideal for the treatment of iron- and steel-based materials, as well as for certain non-ferrous metals and their alloys. Successfully borided parts will have surface layers that improve the durability of mechanical components, which is essential for withstanding a range of industrial operating conditions. Ultra-fast boriding does not create any on-site greenhouse gas emissions or waste and is over eight times faster and 80% more energy efficient than conventional pack boriding.

Project Partners

Argonne National Laboratory
Argonne, IL

Bodycote Thermal Processing - Americas
New Berlin, WI

Ultra-High-Efficiency Aluminum Production Cells

Innovations in the design of molten salt electrolytes, metal inert anodes and wetted cathodes are being evaluated to improve cell efficiency and achieve environmental benefits that are currently unattainable with classic Hall-Héroult cell designs used for aluminum production. The impacts that sodium fluoride (NaF) concentration in molten salt electrolytes have on cell performance and anode stability are being evaluated to develop inert anode aluminum electrolysis cell technology and novel low-temperature electrolytes. The new technology would replace existing cells in aluminum smelters and take advantage of the existing infrastructure for cell feeding, aluminum product casting and shipping, and electrical power supply. The successful combination of inert anode technology with wetted cathode technology has the potential to save up to 25% of the energy used in the high-temperature electrochemical production of aluminum.

Project Partners

Argonne National Laboratory
Argonne, IL

Kingston Process Metallurgy
Kingston, ON

Noranda Aluminum, Inc.
New Madrid, MO

Rapid Conditioning for Next-Generation Melting

A next-generation melting system (NGMS) is being developed to produce high-quality glass from an oxy-gas-fired submerged combustion melter (SCM). NGMS is meant to produce uniform and stone-free glass compositions from less expensive and less complex furnaces than those conventionally used. Researchers are evaluating promising approaches to the rapid conditioning of homogeneous glass produced by a SCM, as well as the design of a pilot-scale NGMS system for fiberglass recycling. This project is also analyzing external rapid conditioning techniques to produce higher quality glass. Improved SCM processes are projected to reduce energy use by up to 23% and reduce refractory usage by up to 80%.

Project Partners

Gas Technology Institute
Des Plains, IL

New York State Energy Research and Development Authority
Albany, NY

Johns Manville
Littleton, CO

Owens Corning
Granville, OH

Energy Saving Melting and Revert Reduction Technology

The Advanced Technology Institute developed the Energy-Saving Melting and Revert Reduction Technology (E-SMARRT) program, a balanced portfolio of projects to optimize energy-saving opportunities for metalcasting. This portfolio of projects targets improvements in melting efficiency; innovative casting processes for yield improvement and revert reduction; improvements in instrumentation and control; and improvements in material properties for casting or tooling design. The E-SMARRT program engages researchers in over 100 industrial companies and national laboratories and utilizes a multifaceted approach to reduce the metalcasting industry's energy consumption by 14% within 10 years. Developments in metalcasting will impact many sectors, including transportation, energy, aerospace, manufacturing, and national defense. Since nearly all manufactured durable goods contain at least one cast metal component, these projects avoid the risks involved with pursuing a single technology within the diverse metalcasting industry, and do not require major capital investments.

Project Partners

Advanced Technology Institute
Charleston, SC

American Foundry Society
Schaumburg, IL

North American Die Casting Association
Wheeling, IL

Steel Founder's Society of America
Crystal Lake, IL

Minimization of Blast Furnace Fuel Rate by Optimizing Burden and Gas Distribution

A novel gas distribution model using high-fidelity computational fluid dynamics (CFD) numerical simulations can improve the performance of blast furnaces. The gas distribution (i.e., the effective contact between the gaseous reductant and the iron ores) strongly influences both the thermal and chemical performances of the furnace. When completed, the state-of-the-art, 3-D, CFD model will allow researchers to evaluate existing designs and simulate computer experiments to optimize burden and gas distributions. This will enable high pulverized coal injection rates and low coke rates, and result in lowered carbon emissions and energy savings of 14%.

Project Partners

American Iron and Steel Institute
Washington, DC

Purdue University Calumet
Calumet, IN

ArcelorMittal USA
East Chicago, IN

ArcelorMittal Dofasco
Hamilton, ON

Severstal North America
Detroit, MI

U.S. Steel
Pittsburgh, PA

U.S. Steel Canada
Hamilton, ON

Union Gas
Chatham, ON

Paired Straight Hearth Furnace – Transformational Ironmaking Process

The paired straight hearth furnace (PSHF) process is being developed as an alternative technology to traditional blast furnace ironmaking. The cokeless PSHF process uses non-metallurgical coal as a reductant to convert iron oxides into direct reduced iron pellets, using about two-thirds as much energy as conventional ironmaking processes. This project is addressing critical furnace engineering and scale-up challenges that must be resolved before proceeding to the design and construction of a pilot-scale facility. The PSHF can produce pellets for use in electric arc furnace steelmaking or molten metal that are similar to blast furnace iron and suitable for use in basic oxygen steelmaking furnaces.

Project Partners

American Iron and Steel Institute
Washington, DC

McMaster University
Hamilton, ON

Coleraine Materials Research Lab
Coleraine, MN

U.S. Steel
Pittsburgh, PA

ArcelorMittal USA
East Chicago, IN

Bricmont, Inc.
Cannonsburg, PA

Isothermal Melting

The isothermal melting system provides die casters and large-scale aluminum operations with a highly energy-efficient technology for melting aluminum and then delivering and dispensing the molten metal to casting operations. Researchers are developing this unique combined system, which uses high-flux, direct-immersion or in-wall electric heaters both in the melter and the turbo-electric delivery ladle. By dramatically improving the 20%–40% thermal efficiencies of un-recuperated, gas-fired reverberatory furnaces, the isothermal melter can reduce energy use by 85% or more. The system will also improve the utilization of melter floor space at secondary aluminum alloy processing operations, eliminate holding furnaces at shape casting facilities, provide in-line temperature control and alloy chemistry flexibility, and raise the quality of molten metal to near aircraft casting standards.

Project Partners

Apogee Technology, Incorporated
Verona, PA

General Motors Company Powertrain Division Saginaw Motors Casting Operation
Saginaw, MI

Aleris International, Inc. Saginaw Facility
Saginaw, MI

WASTE HEAT MINIMIZATION AND RECOVERY

Waste heat minimization and recovery equipment and technologies convert, transport, manage, and recover or reuse energy for industrial processes. Minimizing and/or recovering industrial waste energy is one of the largest opportunities to save energy and improve overall manufacturing energy efficiency.

Improved Heat Recovery in Biomass-Fired Boilers

Corrosion mitigation strategies are being studied to maximize the efficiency of the superheater, an important component of biomass-fired boilers. Current industry practices compromise boiler efficiency by reducing superheater temperatures to avoid accelerating the corrosion of tubes exposed to molten, contaminated deposits from combustion exhaust gases. High-performance materials and coatings are being evaluated to improve the life span of boiler superheater tubes that operate at temperatures above deposit melting points. The ability to withstand corrosive superheater environments has the potential to increase power production by 25% and allow boilers to operate at higher temperatures and pressures.

Project Partners

Oak Ridge National Laboratory
Oak Ridge, TN

FPInnovations-Paprican
Vancouver, BC

SharpConsultant
Columbia, MD

Georgia Institute of Technology
Atlanta, GA

Approximately 15 other industrial, cost-sharing partners

Modifications and Optimization of the Organic Rankine Cycle

Modifications to organic Rankine cycles (ORCs) are being evaluated to convert low-temperature waste heat from gas turbine or reciprocating engine exhaust to electricity. Researchers are developing a direct evaporator concept design and model that is intended to eliminate the usual secondary heat exchanger loop, which traditionally creates additional costs for each unit, increases the opportunity for component failure, and reduces the conversion efficiency of the system. This technology seeks to reduce up to 20% of ORC costs and will initially be retrofitted for waste heat recovery in engines and turbines. Improvements to ORCs allow certain waste heat recovery opportunities to become economically attractive in a range of industries and processes, including metals and mineral manufacturing, refineries, chemical processing plants, and concrete plants.

Project Partners

Idaho National Laboratory
Idaho Falls, ID

General Electric Corporation, Global Research Center
Niskayuna, NY

Advanced Combustion Diagnostics and Control for Furnaces, Fired Heaters and Boilers

Integrating advanced combustion and fuel measurements into a process control strategy provides reliable, accurate measurement data to optimize combustion and energy use in ethylene pyrolysis furnaces. Advanced combustion diagnostics and rapid fuel Btu content measurements are being used to ensure efficient fuel distribution and to control combustion in furnaces. Tunable diode laser technology is being employed to measure combustion gases in or near the combustion zone and create a measurement grid for furnace optimization. These techniques are to provide rich information to enhance existing models, achieve more uniform heat transfer, minimize undesirable combustion by-products, and reduce energy use by up to 10%.

Project Partners

Dow Chemical Company
Freeport, TX

Analytical Specialties, Inc.
Houston, TX

Thermochemical Recuperation for High-Temperature Furnaces in the Steel Industry

A novel thermochemical recuperation (TCR) technology presents a new opportunity for energy savings in steel reheat furnaces. TCR recovers exhaust gas heat and uses it to transform hydrocarbon fuel into reformed fuel with higher heat content for process heating. The enriched gas, combusted with preheated air, has an increased fuel calorific content of up to 28%. TCR technology can benefit other industries that use high-temperature furnaces, including glass manufacturing and aluminum scrap melting operations.

Project Partners

American Iron and Steel Institute
Washington, DC

Gas Technology Institute
Des Plaines, IL

ArcelorMittal USA
East Chicago, IN

Bloom Engineering
Pittsburgh, PA

Republic Engineered Products
Akron, OH

Thermal Transfer Inc.
Duquesne, PA

Steel Manufacturers Association
Washington, DC

U.S. Steel
Pittsburgh, PA

SUSTAINABLE MANUFACTURING

Sustainable manufacturing reduces energy intensity and waste and improves yields in the supply chain via design modifications, novel materials combinations, and new manufacturing approaches. Opportunities include utilizing new manufacturing options that reduce processing steps, integrating design and process controls into intelligent manufacturing operations, eliminating product losses, and practicing efficient materials handling and transport.

Electrohydraulic Forming of Near Net Shape Automotive Panels

Electrohydraulic forming (EHF) is an automotive panel manufacturing process that reduces the energy needed to produce automotive structures and the energy embedded in vehicles. This research effort is evaluating the feasibility of developing a commercial-scale EHF process based on the high-voltage discharge of capacitors between two electrodes positioned in a fluid-filled chamber. This transformational technology will produce very thin net shape panels, decrease the thickness of materials in automotive structures, and eliminate traditionally energy-intensive processing steps. The EHF process can consolidate forming, piercing, trimming, flanging, and other processes into a single process, eliminating 50% of equipment and equipment-related manufacturing energy consumption for many types of sheet metal panels.

Project Partners

Ford Motor Company
Dearborn, MI

U.S. Steel
Pittsburgh, PA

IAP Research
Dayton, OH

Pacific Northwest National Laboratory
Richland, WA

Troy Tooling Technologies
Fraser, MI

Oakland University
Oakland, MI

Flexible Hybrid Friction Stir Joining Technology

Advancing the friction stir welding (FSW) process can lead to industry-wide adoption of the solid-state joining process previously developed to overcome limitations of traditional fusion welding. A hybrid FSW technology is being developed that can be deployed for on-site construction of large, complex, and typically thick-sectioned structures made of high-performance, high-temperature materials. FSW adoption can reduce the amount of energy consumed during welding by up to 70%, improve welding quality, reduce materials used, and eliminate labor-intensive pre- and post-weld heat treatments. Transforming FSW from a specialty welding process into a technology with a broad range of applications can lower costs while increasing the competiveness of many industrial sectors, including aerospace, automotive, chemicals, oil and gas, power generation, and shipbuilding.

Project Partners

Oak Ridge National Laboratory
Oak Ridge, TN

ExxonMobil Upstream Research Company
Houston, TX

MegaStir Technologies
West Bountiful, UT

Induction Consolidation and Molding of Thermoplastic Composites Using Smart Susceptors

This effort is exploring the feasibility of induction consolidation and molding of thermoplastic composites for real-world applications in the automotive, aerospace, and wind energy markets. Additionally, it will evaluate the technology's ability to increase the performance and affordability of components produced while reducing the cycle time and the amount of energy used in manufacturing. Smart susceptors eliminate the need to heat the tooling, which is required in conventional composite manufacturing methods, and the induction molding process can be 40%–75% more efficient than competing processes used to make such components. Thermoplastic resin properties also allow this material to be repeatedly melted and consolidated at lower temperatures, making it a good candidate for recycling and enabling rapid component manufacturing cycles. These lightweight components can replace steel and thermoset materials in vehicles, helping to reduce fuel consumption and carbon emissions.

Project Partners

The Boeing Company
Seattle, WA

Ford Motor Company
Dearborn, MI

Cytec Engineered Materials
Anaheim, CA

Steeplechase Tool & Die Inc.
Lakeview, MI

Temper, Inc.
Rockford, MI

Vestas Wind Systems
Portland, OR

Ajax TOCCO, Inc.
Warren, OH

Near Net Shape Manufacturing of New Titanium Powders for Industry

Near net shape manufacturing of new titanium powders can create a paradigm shift in the titanium market by enhancing current processes that reduce titanium into a powder metal form. Researchers are evaluating innovative technologies capable of processing new titanium powders into fully consolidated, near net shape components at a much lower cost than conventional processing routes. The new approach can reduce the cost of titanium parts by 50%–95% while reducing process energy use by 50%. In addition, producing titanium components fabricated from powder metallurgy can generate less than 5%–10% metal scrap. Improving titanium recyclability, reducing the cost of components, and shortening the length of manufacturing cycles will benefit the aerospace, automotive, chemical processing, and power generation industries.

Project Partners

Oak Ridge National Laboratory
Oak Ridge, TN

Lockheed Martin Aeronautics
Marietta, GA and Fort Worth, TX

Ohio State University
Columbus, OH

Ametek, Inc.
Wallingford, CT

LMC, Inc.
DeKalb, IL

Aqua-Chem, Inc.
Knoxville, TN

Ultra-Efficient and Power-Dense Electric Motors

Researchers are developing line-start and line-run constant-speed electric motors and simple-to-control electric motors that have the ability to reduce motor losses by at least 15%–30%. New general purpose motor technology with a variable-speed drive can be used without a rotor position feedback device, which allows for stable operation at any speed. These ultra-efficient motors are intended to be 30% smaller in volume, 30% lighter in weight, easier to install, and more efficient than current alternatives. Ultra-efficient and high power density electric motors will be suitable for nearly all commercial and industrial motor applications.

Project Partners

Baldor Electric Company
Greenville, SC

Stephen Umans
Belmont, MA

Highly Energy-Efficient Directed Green Liquor Utilization Pulping

The directed green liquor utilization pulping process uses a pulping by-product to improve the yield of Kraft pulp and the economics of pulping operations. An engineering design and implementation plan for the new process is being developed to optimize the use of green liquor, a readily available resource in Kraft pulp mills, as part of a pre-treatment stage to improve Kraft pulping. This effort will determine how to handle green liquor flows, evaluate pulping catalysts, explore mill-specific issues, and perform mill trials. Implementing this retro-modification in Kraft pulp mills can reduce energy intensity by 20%–30%, increase cellulose retention, increase pulp yields by 3%–5%, and increase machine speeds by 15%.

Project Partners

North Carolina State University
Raleigh, NC

Georgia Institute of Technology
Atlanta, GA

MeadWestvaco Corporation
Evadale, TX

Hot Rolling Scrap Reduction through Edge Cracking and Surface Defects Control

Integrated computer models and process optimization tools, which relate structural properties to manufacturing processes with the materials used, are being designed to reduce hot rolling scrap that results from edge cracking and surface defects. Hot rolling large ingots to produce plate, sheet, and foil aluminum products has a typical recovery rate of 82%, with 18% of the original material lost as scrap. Integration of microstructure characterization, computational modeling of microstructures and fracture nucleation, 3-D rolling modeling, and process optimization approaches can lead to thorough understanding of material responses to the hot rolling process. These models will serve as efficient design tools to increase process efficiency and reduce scrap generation from edge cracking and rolling surface defects by 50%.

Project Partners

University of Illinois at Urbana-Champaign
Urbana, IL

Alcoa, Inc.
Alcoa Center, PA

Lawrence Livermore National Laboratory
Livermore, CA

Ohio State University
Columbus, OH

Northwestern University
Evanston, IL

Renewable Microbial Polyesters for Cost-Effective and Energy-Efficient Wood-Plastic Composites

A cost-effective process to make wood-plastic building materials using unpurified, renewable, and biodegradable bio-based composites can replace the use of petroleum-derived plastics. Polyhydroxyalkanoates (PHA), or microbial thermoplastic polyesters, will be produced from waste effluents and bacteria inherent to the mill's

Project Partners

Idaho National Laboratory
Idaho Falls, ID

Washington State University
Pullman, WA

ECO:LOGIC, Inc.
Rocklin, CA

Glatfelter Corporation
Chillicothe, OH

Strandex Corporation
Cincinnati, OH

University of California-Davis
Davis, CA

wastewater treatment processes to reduce substrate costs for building materials. Eliminating purification steps to remove cell debris and reducing feedstock use can decrease PHA-composite production costs by 40%.

Screenable Wax Coatings and Water-Based Pressure Sensitive Adhesives

Water-based pressure sensitive adhesives (PSAs) and screenable wax coatings that can be easily removed early in the paper recycling process can solve several problems for recycling pulp mills. These advances will allow paper carrying adhesives and wax-coated containers to be processed and recycled, preventing high-grade paper from ending up in landfills and increasing the recovery rate of corrugated containers by 6%. Researchers are evaluating models to improve the properties of water-based PSAs and wax coatings, improve components that affect fragmentation during repulping and the efficiency of subsequent screening processes, and reduce factors that diminish recycling performance—without increasing costs or sacrificing performance. Improving the paper recyclability of wax-coated or adhesive-carrying containers can reduce paper processing energy, yield higher quality products, and avoid excess landfill by-products.

Project Partners

University of Minnesota
Twin Cities, MN

USDA Forest Service
Madison, WI

Franklin International
Columbus, OH

The International Group, Inc.
Toronto, ON

Boise Cascade Corporation
International Falls, MN

Wireless Monitoring of Steel Production Facilities

New wireless sensors, actuators, and networks can be used to optimize operations in steel manufacturing facilities. The sensor data, along with the appropriate software, can be used to perform baseline comparisons among multiple mills, obtain benchmark energy consumption information before and after modifications, and estimate energy savings on a percent-operating basis. Using commercial, off-the-shelf equipment, the system will measure and potentially control energy consumption in air, steam, electrical, and other systems within integrated mills and mini-mills. An example application is monitoring the water temperature and flow rate in the water-cooled circuits of an electric arc furnace's (EAF) roof, sidewalls, burners, and ductwork, and providing a continuous energy balance around the EAF. This is estimated to reduce electricity use by 5%, provide increased operator awareness, and lead to more consistent operations and increased system availability.

Project Partners

Oak Ridge National Laboratory
Oak Ridge, TN

CMC Steel South Carolina
Cayce, SC

U.S. Steel
Braddock, PA

The Industrial Technologies Program (ITP) is the lead government program working to increase the energy efficiency of U.S. industry—which accounts for about one-third of U.S. energy use. In partnership with industry, ITP helps research, develop, and deploy innovative technologies that companies can use to improve their energy productivity, reduce carbon emissions, and gain a competitive edge.

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