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

INDUSTRIAL TECHNOLOGIES PROGRAM

Grand Challenge Portfolio:
Driving Innovations in Industrial Energy Efficiency

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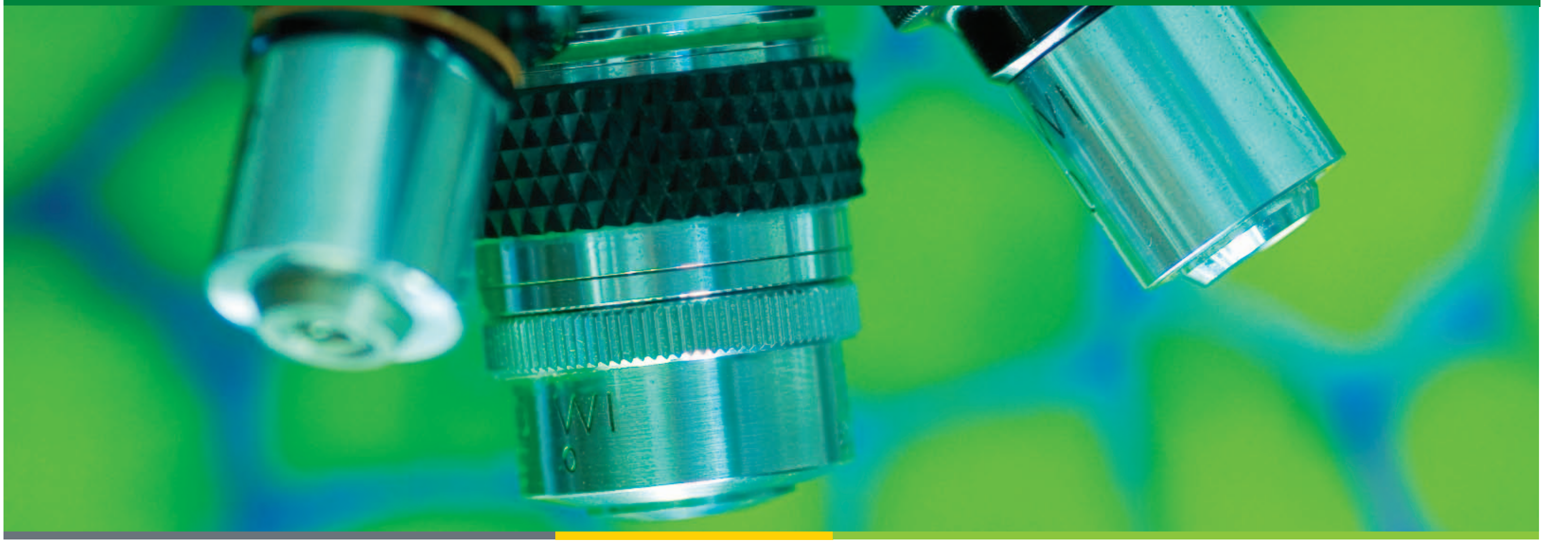


INTRODUCTION

The Grand Challenge portfolio targets high-risk, high-value research and development focused on energy efficiency that industry would not typically pursue without federal leadership and the support offered by a public-private partnership. Collaborative teams from industry, academia, and the national laboratories—nearly 90 partners in total—are sharing the costs and risks of these cutting-edge research studies.

The Department of Energy's (DOE's) Industrial Technologies Program (ITP) has provided $13 million in funding for 47 concept definition studies that seek revolutionary solutions to reduce energy use and carbon emissions in manufacturing. With this portfolio, ITP is pursuing a relatively large number of projects with limited funding ($300,000 or less) to focus the best minds in the nation on resolving industry's challenges. The concept definition studies will use early-stage research, laboratory-scale experiments, data generation and analysis, and other exploratory methods to advance new, dramatically different manufacturing concepts and practices.

The portfolio pursues innovation in four topic areas:

- **Next-generation manufacturing concepts**
- **Energy-intensive processes**
- **Advanced materials**
- **Industrial greenhouse gas emissions reduction**

Each study in the portfolio has a defined goal, provides a solution to a major technical issue, or seeks to overcome the technical barriers in taking a concept to the next level to achieve a technological breakthrough. The breakthrough must reduce energy intensity (Btu per unit output) or greenhouse gas emissions by a specified amount while providing a return on investment compared to today's industrial systems.

A list of the 47 concept definition studies by topic area and a description of each study follows.

> "Public-private partnerships with industry are a critical way to accelerate the transition to a strong, competitive, clean energy economy in the United States."
>
> — Steven Chu, U.S. Secretary of Energy

List of Grand Portfolio Projects by Topic

Next-Generation Manufacturing Concepts

Energy-Saving Glass Lamination via Selective Radio-Frequency Heating

Friction Stir Processing for Efficient Manufacturing

Dry Kraft Pulping at Ambient Pressure for Cost-Effective Energy Savings and Pollution Deductions

Use of Microwave for Energy-Efficient Heating in High-Temperature Brazing

Autothermal Styrene Manufacturing Process with Net Export of Energy

Advanced Production Surface Preparation Technology for Ultra High-Pressure Diesel Injection

Efficient, One-Step Electrolytic Recycling of Low-Grade and Post-Consumer Magnesium Scrap

Novel Membranes and Processes for Oxygen Enrichment

Electrical-Assisted Double Side Incremental Forming Process for Enhanced Sheet Metal Formability and Geometrical Flexibility

Methyl Chloride from Direct Methane Partial Oxidation: A High-Temperature Shilov-Like Catalytic System

Direct Solid-State Conversion of Recyclable Metals into Nanoengineered Bulk Materials

Reduction of Metal Oxide to Metal Using Ionic Liquids

Print-Based Manufacturing for Photovoltaics and Solid-State Lighting

Energy-Intensive Processes

Membrane Purification Cell for Aluminum Recycling

Production of Energy Efficient Preform Structures

Engineered Osmosis for Energy-Efficient Separations: Optimizing Waste Heat Utilization

Energy Reductions Using Next-Generation Remanufacturing Techniques

Novel Steels for High-Temperature Carburizing

Microwave Enhanced Direct Cracking of Hydrocarbon Feedstock for Production of Ethylene and Propylene

Energy-Efficient Microwave Hybrid Processing of Lime for Cement, Steel, and Glass Industries

Environmentally Friendly Coolant System

Waste Heat Recovery and Recycling in Thermal Separation Processes

Advanced Energy and Water Recovery Technology from Low-Grade Waste Heat

Advanced Optical Sensors to Minimize Energy Consumption in Polymer Extrusion Processes

Near Net-Shaped Fabrication Using Low-Cost Titanium Alloy Powders

Advanced Nanostructured Molecular Sieves for Energy-Efficient Industrial Separations

New Manufacturing Method for Paper Filler and Fiber Materials

Integrated Ammonia Reactor and Ammonia Pressure Swing Adsorption Recovery

Ultra-High Efficiency and Ultra-Low Emissions Crosscutting Combustion Technology for Manufacturing Industries

Solid-Fuel Oxygen-Fired Production of Nodular Reduced Iron

Machining Elimination through Application of Thread Forming Fasteners in Net-Shaped Cast Holes

A New Method for Producing Titanium Dioxide Pigment and Eliminating CO_2 Emissions

Distributive Distillation Enabled by Microchannel Process Technology

Advanced Materials

Aerogel-Based Insulation for High-Temperature Industrial Processes

Ultra-Thin Quantum Well Materials

Thermal and Degradation Resistant Stainless Steel for Industrial Use

Nanostructured Ferritic Alloys: Improving Manufacturing Energy Efficiency and Performance for High-Temperature Applications

New High-Temperature, Low-Cost Ceramic Media for Natural Gas Combustion Burners

Ultracoatings: Next-Generation Nanocoatings for High-Contact Stress Environments

Low-Cost Production of InGaN for Next-Generation Photovoltaic Devices

Multiphase Nanocomposite Coatings for Energy Optimization

Industrial Greenhouse Gas Emissions Reduction

Next-Generation Wireless Instrumentation Integrated with Mathematical Modeling for Use in Aluminum Production

Removal of Volatile Organic Compounds and Organic Hazardous Air Pollutants from Industrial Waste Streams by Direct Electron Oxidation

Hydrate-Free Concrete: A Low Energy, CO_2-Negative Solution

Crude Glycerol as Cost-Effective Fuel for Combined Heat and Power to Replace Fossil Fuels

New Silica-Alumina-Based Cementitious Material Using Coal Refuse

High Power Industrial Ultraviolet Curing Systems

NEXT-GENERATION MANUFACTURING CONCEPTS

Next-generation manufacturing studies seek new manufacturing concepts that can potentially replace conventional manufacturing processes and reduce the energy intensity or greenhouse gas emissions of industrial systems by 25% or more.

Energy-Saving Glass Lamination via Selective Radio-Frequency Heating

The manufacturability of a radio-frequency (RF) heating process will be investigated to reduce glass lamination time and significantly lower energy intensity. RF heating saves energy by dissipating RF energy as heat into the vinyl layers without heating the glass and has been shown to reduce lamination time to 1-3 minutes. The manufacturability potential will be evaluated by researching concepts for curved RF glass lamination, investigating safety and regulatory hurdles, and defining energy and environmental impacts from widespread use of the RF material. Adoption of this process will also lower the cost of laminated products, such as automotive side windows and solar panels. The project seeks to use RF heating to reduce energy use in glass lamination production by up to 90%.

Project Partners

Ceralink, Inc.
Rensselaer, NY

Thermex Thermatron
Louisville, KY

University of Illinois at Urbana-Champaign
Urbana, IL

Pilkington, NSG Group Flat Glass Business
Northwood, OH

Friction Stir Processing for Efficient Manufacturing

Friction Stir Processing (FSP) is an innovative surface hardening technique for metallic materials and components with the potential to replace traditional high-cost, energy-intensive surface technologies. This technology will be evaluated for reducing friction losses and enhancing wear performance for steel surface hardening. FSP features a rotating tool that is plunged to a predetermined depth and manipulated to heat and cause plastic deformation of the processing area. This process seeks to save time and energy, versus conventional surface hardening techniques, and eliminate quenchants and other chemicals. The project will demonstrate a surface hardening treatment that has the potential to reduce energy use by 70% compared to conventional thermal heat treatments.

Project Partners

Friction Stir Link, Inc.
Waukesha, WI

Argonne National Laboratory
Argonne, IL

Dry Kraft Pulping at Ambient Pressure for Cost-Effective Energy Savings and Pollution Deductions

A new dry kraft pulping technology is being investigated to replace current kraft pulping processes that rely heavily on energy-intensive black liquor treatments. This dry method is based on the concept of depolymerizing lignin in wood chips at ambient pressure without the need for a water medium and will be optimized to overcome the disadvantages of conventional kraft pulping. This process will save energy by reducing the amount of black liquor treatments, speeding up the pulping production rate, and eliminating high-cost pressurized digester equipment. This process seeks to reduce energy use in the cooking process by 40% and chemical use by 50% due to a reduction in black liquor treatments.

Project Partners

Georgia Institute of Technology
Atlanta, GA

Use of Microwave for Energy-Efficient Heating in High-Temperature Brazing

A novel microwave brazing technology enables metal casting and fabricated metal producers to effectively apply microwave energy—one of the most efficient sources of energy—for joining and repairing metal parts. Bulk metals do not absorb microwave energy, but this process forms microwave plasma at the braze site and produces intense local heating to join metallic components efficiently. This process, demonstrated in the laboratory, will be tested for application in industrial components to ensure good melting and braze flow. The project seeks to improve energy efficiency by 50% compared to conventional vacuum brazing. The results of this study can be used to design a commercial-scale system, which will impact jet engines and industrial gas turbine production.

Project Partners

GE Global Research
Niskayuna, NY

Autothermal Styrene Manufacturing Process with Net Export of Energy

This concept definition study focuses on developing a styrene monomer (SM) processing technology that reduces life cycle process energy requirements by 25% compared to conventional technology. Researchers will identify new catalysts for SM production, develop the conceptual design of a production facility, and formulate a demonstration plan. DOE has identified SM as the ninth-ranked organic chemical on a total production volume basis and having the third-highest potential for process energy savings.

Project Partners

Lummus Technology
Bloomfield, NJ

Advanced Production Surface Preparation Technology for Ultra High-Pressure Diesel Injection

Ultra high-pressure diesel injection engines—currently targeted for use in electric power generation and marine power engines—must comply with 2014 Tier 4 emissions standards and provide a projected 2.5% improvement in fuel economy. The project seeks to develop methods to impart more than 700 megapascals (MPa) of compressive residual stress and near-perfect design geometry (within plus or minus 0.5 micrometers) on all surfaces that contact the ultra-high injection pressure while using traditional fuel system engineering materials. This study will also develop methods to prepare key surfaces of the fuel system for compressive residual stress and pulsating movements without causing fatigue failure.

Project Partners

Caterpillar Inc.
Mossville, IL

Efficient, One-Step Electrolytic Recycling of Low-Grade and Post-Consumer Magnesium Scrap

A single-step magnesium scrap recycling process melts low-grade magnesium scrap and refines it to a pure product using solid oxide membrane (SOM) electrolysis. SOM electrolysis continuously feeds magnesium oxide into a molten salt bath where electricity splits it into magnesium metal vapor and oxygen gas in separate chambers. While increasing the magnesium recycling rate, this technology will lower costs, save energy, and reduce carbon emissions in production. Increased use of magnesium in automotive parts will also result in transportation fuel savings from lighter vehicles. The project will design a small (30 to 60 ton/yr) reactor which demonstrates all of the features of the process and has the potential to reduce energy costs by 70% compared to primary production.

Project Partners

Metal Oxygen Separation Technologies, Inc.
Natick, MA

Boston University
Boston, MA

Novel Membranes and Processes for Oxygen Enrichment

This concept definition study focuses on the development of an effective system that produces oxygen-enriched air using less energy and at one-third the cost of today's processes. Cheaper oxygen-enriched air will increase the economic attractiveness of converting existing air-fueled furnaces to oxygen-enriched furnaces, which will significantly improve the efficiency of industrial combustion processes by 50% to 70% while reducing greenhouse gas emissions. The newly discovered polymers are ten times more oxygen-permeable than conventional membrane materials.

Project Partners

Membrane Technology and Research, Inc.
Menlo Park, CA

Tetramer Technologies, LLC
Pendleton, SC

Gas Technology Institute
Des Plaines, IL

Electrical-Assisted Double Side Incremental Forming Process for Enhanced Sheet Metal Formability and Geometrical Flexibility

A new process enhances the formability and fabrication of sheet metals for producing targeted components in the aerospace, automotive, appliance, and medical device industries by combining the double-sided incremental forming process with the use of pulsed electric current into one synergistic process. In Electrical-Assisted Double Side Incremental Forming (EADSIF), a forming tool moves along a pre-defined tool path, while locally deforming a flat, peripherally-clamped sheet metal blank. This process, already proven to improve formability at room temperature, will enable fabricators to create more complex parts while reducing energy requirements and emissions. The project seeks to eliminate 100% of dies and forming presses used in traditional sheet drawing processes.

Project Partners

Northwestern University
Evanston, IL

Ford Motor Company
Dearborn, MI

Penn State Erie, The Behrend College
Erie, PA

Massachusetts Institute of Technology
Cambridge, MA

Methyl Chloride from Direct Methane Partial Oxidation: A High-Temperature Shilov-Like Catalytic System

A single-step, low-temperature (<300°C) partial-oxidation process will convert low-grade natural gas directly to methyl chloride—a widely used chemical that can be converted to important products or liquid fuels. Using "designer" ionic liquids and Shilov-like catalysts for partial oxidation, this process could replace multi-step, energy-intensive processes that involve higher temperature (>500°C) syngas generation, thereby significantly reducing energy intensity and greenhouse gas emissions by 50% to 60%. This project will develop and optimize the new methane catalytic system.

Project Partners

Power Environmental and Energy Research Institute
Covina, CA

Direct Solid-State Conversion of Recyclable Metals into Nanoengineered Bulk Materials

The feasibility of a direct, solid-state metal conversion (DSSMC) process will be explored for converting aluminum and copper scrap into marketable forms without requiring melting and casting operations. DSSMC consolidates and converts powders, chips, or other recyclable feedstock metals or scraps directly into usable product forms without re-melting the feedstock. The project will also demonstrate the feasibility of utilizing nanoparticle, dispersion-strengthened bulk materials and/or nanocomposite materials for target applications in future electric power generation and delivery infrastructure, and in lightweight structures for automotive applications. The project aims to reduce energy use of conventional metal casting processes by 80%.

Project Partners

Southwire Company
Carrollton, GA

Oak Ridge National Laboratory
Oak Ridge, TN

Reduction of Metal Oxide to Metal Using Ionic Liquids

A transformational low-temperature process will be developed to extract metals from metal oxides, particularly metallic silicon (Si) from silica (SiO_2), using ionic liquids and electrolytic reduction at low temperatures. Researchers will identify suitable ionic liquids to dissolve the metal oxides, characterize the properties of the melts, optimize the electrolysis process, and make recommendations for process optimization and scale-up. Reducing metal oxides to metals through ionic liquid electrolysis will enable the domestic metals industry to save energy and costs by replacing conventional high-temperature chlorination and carbon-reduction processes. The project aims to improve energy efficiency by 36% compared to conventional extraction processes.

Project Partners

The University of Alabama
Tuscaloosa, AL

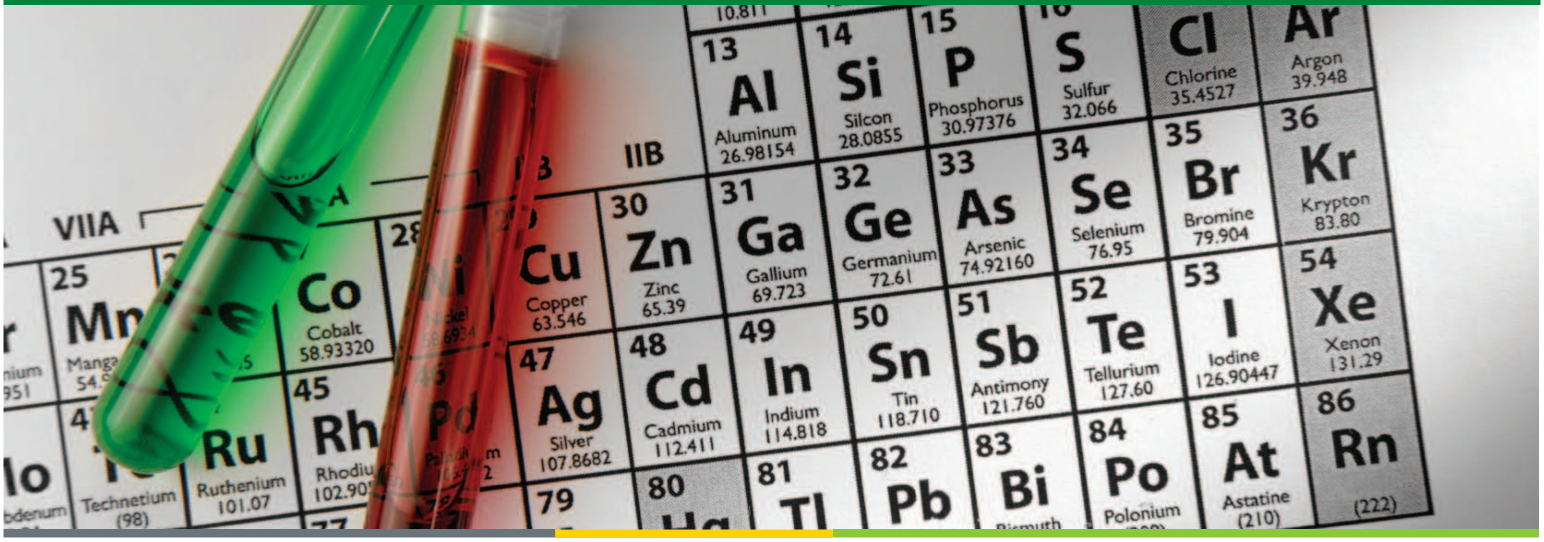
Print-Based Manufacturing for Photovoltaics and Solid-State Lighting

A transformational print-based manufacturing process for fabricating photovoltaics and solid-state lighting could significantly reduce the energy consumption and greenhouse gas emissions associated with conventional manufacturing methods by 50%. This study demonstrates the manufacture of photovoltaics on barrier plastic substrates using a screen-printing pilot line process. The aim is to define next-generation, print-based manufacturing plants to fabricate commercially-competitive organic light emitting diodes (OLED) and photovoltaic panels to replace conventional lighting.

Project Partners

University of California
Santa Cruz, CA

Add-Vision, Inc.
Scotts Valley, CA



ENERGY-INTENSIVE PROCESSES

Energy-intensive process studies concentrate on reactions and separations, high-temperature processing, waste-heat minimization and recovery, sustainable manufacturing, and other technology areas that can generate large energy-saving benefits in major manufacturing processes across a variety of industries.

Membrane Purification Cell for Aluminum Recycling

A membrane purification cell technology will be evaluated to increase aluminum recycling and enable mixed-alloy streams to be treated and recycled. A fluoride electrolyte system will be evaluated to position the membrane purification technology for multi-day operation with stable cell voltage. This technology will improve recyclability by reducing or eliminating the amount of primary aluminum that needs to be added to the waste stream to offset contamination. Primary aluminum production requires ten times more energy than scrap melting processes. The planned membrane cell seeks to reduce energy consumption for producing high-purity aluminum by 75% and the energy content of recycled metal by 70%.

Project Partners
Alcoa, Inc.
Pittsburgh, PA

Production of Energy Efficient Preform Structures

Ultra net-shape preforms, or shapes close to a final product's dimensions, will enable manufacturers of large structures (e.g., aerospace components) to save energy through reduced machining and subsequent recycling. These producers must typically remove vast amounts of material from standard mill products, generating large amounts of scrap that must be recycled. A new fabrication method will use solid-state joining techniques to produce complex ultra net-shape preforms that are closer to a finished part's dimensions and allow large and bulk product producers to optimize material use. These techniques do not use high-energy discharge to melt material, further saving energy and minimizing the need for raw material processing and transportation. The project seeks to eliminate 90% of material waste when manufacturing large aerospace structures.

Project Partners
The Boeing Company
Seattle, WA

Engineered Osmosis for Energy-Efficient Separations: Optimizing Waste Heat Utilization

Components of a transformative osmosis-based wastewater treatment technology will be redesigned to prepare the technology for full-scale piloting in an industrial facility. The separation process uses low-grade waste heat to produce clean, fresh water from industrial wastewaters, seawater, sewage, and other contaminated waters. The process could be retrofitted to existing industrial facilities and could expand into the desalination market.
This technology seeks to reduce separation electricity usage by 87% over market-leading reverse osmosis processes.

Project Partners
Oasys Water, Inc.
Cambridge, MA

Energy Reductions Using Next-Generation Remanufacturing Techniques

A laser-assisted two-wire arc thermal spraying re-surfaces worn or damaged steel- or aluminum-based parts while providing better metallurgical bonding and durability. This new process ensures a reliable mechanical bond using a hybrid approach of combining a focused laser beam to thermally treat the substrate surface immediately prior to a thermally-sprayed powder treatment. This approach will be optimized to enable the remanufacturing of components in engine drive trains and undercarriage systems, which are vital to machines and engines operated in several industries. Reliable remanufactured parts will extend product life cycle and avoid costly replacements. The project seeks to reduce the energy required to produce a new part by up to 85%.

Project Partners

Caterpillar Inc.
Mossville, IL

Novel Steels for High-Temperature Carburizing

A generic composition-based practice will be developed to maintain fine austenite grain size in low-alloy carburizing steels. Researchers will determine whether low-alloy steel compositions allow for case carburizing at higher temperatures without adversely affecting product performance. This will lead to the development of a new family of commercial carburizing alloys that can find application in the petroleum, chemical, forest products, automotive, mining, and industrial equipment industries. Inhibiting undesirable grain modifications will enable the use of high-temperature carburization, with the potential to reduce energy use by 55% relative to conventional carburization processes.

Project Partners

Caterpillar Inc.
Mossville, IL

Advanced Steel Products and Processing Research Center (Colorado School of Mines)
Golden, CO

Microwave Enhanced Direct Cracking of Hydrocarbon Feedstock for Production of Ethylene and Propylene

Key technical concepts will be defined to enable direct microwave treating for hydrocarbon cracking as a replacement for energy-intensive indirect heating methods in the production of ethylene, one of the largest volume chemicals produced. Hydrocarbon/microwave interaction mechanisms will be modeled and evaluated on precursors and products of ethylene production.

This process has the potential to reduce the energy required for cracking, the most energy-intensive process in the chemical industry, by at least 50%. In addition, the temperature on the reactor skin can be reduced, thereby minimizing coke build-up on the reactor wall and prolonging cracker efficiency and operational time.

Project Partners

Ceralink, Inc.
Troy, NY

Rennselaer Polytechnique Institute
Troy, NY

Technip
Claremont, CA

John Balsam Associates, LLC
Missoula, MT

Energy-Efficient Microwave Hybrid Processing of Lime for Cement, Steel, and Glass Industries

A hybrid microwave processing technology will reduce the energy required for lime and cement production, particularly during the calcinations of limestone. Microwave Assist Technology (MAT) simultaneously applies radiant heat and microwave energy in the same kiln, which could drastically reduce process time and energy consumption. Interactions between microwaves and materials will be studied, modeled, and evaluated for material reactions and energy use. Early-stage equipment design concepts will be developed and evaluated for possible retrofitting. Use of MAT will enable the limestone calcination process to run at twice the speed, potentially reducing energy use by approximately 50%.

Project Partners

Ceralink, Inc.
Troy, NY

Worcester Polytechnic Institute
Worcester, MA

Rensselaer Polytechnic Institute
Troy, NY

Mississippi Lime
Ste. Genevieve, MO

Chemical Lime Company
Fort Worth, TX

Harrop Industries, Inc.
Columbus, OH

Thermex Thermatron
Louisville, KY

Western Lime Corporation
Westbend, WI

Environmentally Friendly Coolant System

The Environmentally Friendly Cooling System (EFCS) uses dry ice CO_2 particles rather than traditional petroleum-based fluids for cooling during machining operations and has the potential to reduce costs in the aluminum, metal casting, and other energy-intensive industries. The EFCS cools surfaces by applying CO_2 particles (and assist gas and bio-oil, if needed) directly to the cutting zone, and improves cutting speeds by removing machined particles from the cutting zone. With the potential to displace petroleum-based machining cooling and lubrication, this technology can find applications in metal machining, composites drilling, and thermal spraying of molten metals. The project seeks to improve machine throughput by 30%, replacing conventional machining operation coolant systems and reducing energy consumption by 25%.

Project Partners

Cool Clean Technologies Inc.
Eagan, MN

Waste Heat Recovery and Recycling in Thermal Separation Processes

Waste-heat powered thermal heat pumps will be evaluated for recovering and recycling at least 50% of latent heat from distillation, crystallization, and evaporation processes. Researchers will perform a systems analysis to determine optimum conditions for recovery and recycling, evaluate a working fluid pair for high-temperature pumps,

Project Partners

FMC Corporation
Princeton, NJ

E3Tec Service, LLC
Clarksville, MD

ChemResearch Engineering, LLC
Bowie, MD

and identify critical needs for improved heat transfer equipment. The results could be used to design and install a pilot plant for further validating the technology.

Advanced Energy and Water Recovery Technology from Low-Grade Waste Heat

A nanoporous membrane-based water vapor separation technology will be developed for recovering energy and high purity water from low-grade, high-moisture industrial waste streams, which are present in many industrial processes. Conventional technologies often cannot recover heat due to low heat transfer and moisture-related corrosion issues. The study will test and prove the nanoporous membrane-based water vapor separation concept and technology in the laboratory and evaluate its performance in two different types of industrial environments. The project seeks to improve the membrane's water and heat recovery capacity, resulting in 20% to 30% greater energy efficiency.

Project Partners

Gas Technology Institute
Des Plaines, IL

Oak Ridge National Laboratory
Oak Ridge, TN

University of Tennessee, Knoxville
Knoxville, TN

Advanced Optical Sensors to Minimize Energy Consumption in Polymer Extrusion Processes

Advanced on-line sensor technology will be developed to monitor the color and composition of polymer melts to eliminate the energy, material, and operation costs associated with recycling off-specification polymer products. Polymer extrusion processes are typically difficult to control, but the development of an effective control algorithm would enable rapid corrections to materials and operating conditions. This information could be used to identify extruder system issues, diagnose problem sources, and suggest corrective actions in real-time. Application of this technology could streamline production of consumer goods, such as pharmaceuticals, beverages, and cleaning products.

Project Partners

Guided Wave, Inc.
Rancho Cordova, CA

PolyOne Corporation
Avon Lake, OH

Near Net-Shaped Fabrication Using Low-Cost Titanium Alloy Powders

A "meltless" approach to titanium fabrication can significantly reduce energy consumption in the aerospace industry by using low-cost titanium powder to make near-net preforms that can be formed easily into structural components. Airframe structural parts will be assessed to design near-net shape strategies for each part. The technical feasibility of producing these shapes with small quantities of low-cost titanium powders will also be evaluated, along with quantification of the energy requirements involved. These steps will help to identify the most sustainable manufacturing approach for reducing scrap formation. The project seeks to establish the technical feasibility of processing titanium powders into fully dense, near-net shaped products and to reduce machining costs by at least 20%.

Project Partners

The Boeing Company
Saint Louis, MO

Oak Ridge National Laboratory
Oak Ridge, TN

Advanced Nanostructured Molecular Sieves for Energy-Efficient Industrial Separations

This project aims to develop mesoporous zeolite-containing adsorbents in simulated moving bed or pressure swing adsorption processes to replace cost- and energy-intensive distillation processes in the chemical and petroleum refining industries. Incorporating mesoporosity into a zeolite adsorbent can increase diffusivity by about 50% while improving the selectivity and rate of adsorption by about 40%. This study focuses on demonstrating the mesoporous zeolite as an adsorbent for the separation of propane from propylene, one of the most energy-intensive, high-volume industrial separations.

Project Partners

Rive Technology, Inc.
Monmouth Junction, NJ

New Manufacturing Method for Paper Filler and Fiber Materials

This study seeks to produce paper grades suitable for printing and writing while increasing the filler content of the paper with a composite produced from kraft and process pulp. Increasing the filler content would reduce the pulp requirement and generate corresponding energy savings for pulp production; however, increased filler content can adversely affect paper quality. This study will investigate a new fiber filler material to resolve these limitations and improve the efficiency of papermaking. If successful, this project could reduce overall energy use by 20% and life-cycle carbon dioxide emissions in papermaking operations by at least 5%.

Project Partners

State University of New York, College of Environmental Science and Forestry
Albany, NY

Integrated Ammonia Reactor and Ammonia Pressure Swing Adsorption Recovery

A new concept increases the yield of ammonia, a widely used chemical, by integrating an enhanced ammonia reactor with a newly developed recovery system to increase ammonia yield while lowering energy and cost requirements. This method introduces only pure reactants into the synthesis reactor, then recovers unused reactants and recycles them back to the reactor free of potential contaminants, such as ammonia and other inert chemicals. Energy savings are derived from recycling without the loss of product or unused reactants and from eliminating the need to recompress or reheat the recycle stream. This process has the potential to save more than 70% of energy and capital cost for each ammonia plant.

Project Partners

SmartKoncept Technology
Houston, TX

Ultra-High Efficiency and Ultra-Low Emissions Crosscutting Combustion Technology for Manufacturing Industries

Radiative Homogenous Combustion (RHC) for high-temperature furnaces incorporates intense radiation from the combustion volume with the newly popular flameless combustion technique and seeks to help manufacturers reduce their energy and carbon intensities. To enable adoption of this technology, researchers will modify the furnace design to increase radiation and validate computational models. Part of the RHC technology will be tested at an aluminum melting furnace. This project seeks to increase furnace productivity by 50%, reducing energy intensity by 33%, greenhouse gas emissions by 70%, and emissions of nitrogen oxides (NOx) by 5 orders of magnitude.

Project Partners

University of Michigan
Ann Arbor, MI

Solid-Fuel Oxygen-Fired Production of Nodular Reduced Iron

A nodular reduced iron (NRI) process produces pig iron-quality nodules that can raise electric arc furnace product quality, replacing scrap. As with most other direct-reduced iron processes, the NRI process currently uses natural gas as a fuel. A process is being evaluated that combines the NRI process with oxygen-fired solid-fuel burners and thermally processed biomass. Researchers are assessing potential energy cost reductions, improved heat transfer, increased product yield, and reduced greenhouse gas emissions. The use of oxy-biomass combustion has the potential to reduce natural gas use by up to 75% and NOx emissions by 84% relative to conventional air combustion.

Project Partners

University of Minnesota
Duluth, MN

Machining Elimination through Application of Thread Forming Fasteners in Net-Shaped Cast Holes

Thread forming fastener (TFF) technology in aluminum and magnesium castings has the potential to reduce the extensive drilling and tapping operations for threaded fasteners performed at automotive engine and transmission plants. A series of experiments are investigating potential barriers to the implementation of thread forming fasteners in aluminum and magnesium castings, such as consistency of clamp load versus torque input and maintaining clamp load as casting dies wear. The project seeks to eliminate approximately 30% of the machining in typical automotive engine and transmission processes by using thread forming fasteners in as-cast holes of aluminum and magnesium cast components.

Project Partners

United States Council for Automotive Research, LLC
Oakland, MI

Ford Motor Company
Dearborn, MI

Acument Global Technologies
Troy, MI

ATF
Lincolnwood, IL

REMINC
Middletown, RI

Tech Knowledge
Grosse Ile, MI

A New Method for Producing Titanium Dioxide Pigment and Eliminating CO_2 Emissions

The potential for a new methodology for titanium dioxide (TiO_2) pigment production is being demonstrated. The innovative method uses chemical sequential treatments and extraction methodology to produce pure TiO_2 with dramatically less CO_2 and environmental waste. The process also eliminates the energy-consuming step of breaking and reforming the Ti-O bond in the titanium ore–ilmenite raw material. The process is anticipated to reduce energy use by 40% compared to conventional processes.

Project Partners

The University of Utah
Salt Lake City, UT

Distributive Distillation Enabled by Microchannel Process Technology

Microchannel process technology can enable distributive distillation—the use of a larger number of smaller distillation units in multiple configurations—to greatly improve efficiency compared to a single distillation column. Early experiments have verified effective, controlled, and highly efficient separation of close boiling mixtures, but the economic viability and manufacturability of commercial-scale, microchannel distillation units is yet to be determined. This effort will ascertain the industrial viability and benefits of microchannel distillation, including the development of market and economic evaluations. This process has the potential to save up to 40% of the energy required by conventional processes.

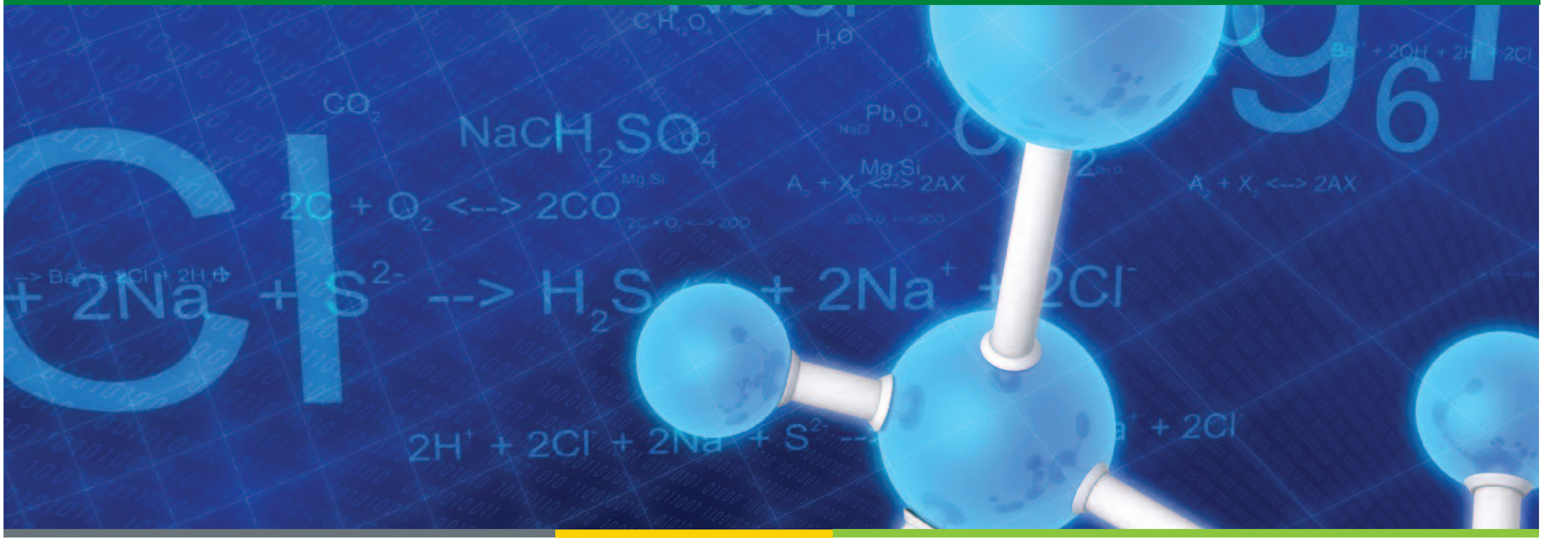
Project Partners

Velocys, Inc.
Franklin, OH

Edison Welding Institute
Columbus, OH

ButylFuel, LLC
Gahanna, OH

U.S. Department of Agriculture, Eastern Regional Research Center
Wyndmoor, PA



ADVANCED MATERIALS

Advanced material studies focus on industrial materials that can last 10 times longer than current materials and operate at higher temperatures, or materials that can improve the performance of energy production and energy transfer equipment by at least 50%.

Aerogel-Based Insulation for High-Temperature Industrial Processes

Pyrogel HT is an industrial insulation product derived from nanoporous silica aerogels that has broad application in glass melting, metal casting, coking, and other energy-intensive processes. The insulation is less costly and 4-5 times more thermally efficient than the current market leaders, mineral wool and calcium silicate. Pyrogel HT achieves low thermal conductivity at temperatures as high as 1,200°F, addressing a gap in available insulation materials for temperatures between 750°F and 1,200°F. Initial development focuses on applications in the power generation industry; using Pyrogel HT to re-insulate the piping and equipment in an industrial facility could reduce piping heat loss by 75%.

Project Partners

Aspen Aerogels, Inc.
Northborough, MA

American Electric Power
Columbus, OH

Ultra-Thin Quantum Well Materials

Ultra-thin quantum well thermoelectric materials are being fabricated for and evaluated in waste-heat generator applications in the aluminum, iron, and steel industries. Thin-film thermoelectrics can provide a large increase in waste heat recovery from industrial processes and deliver a significant advance in cooling efficiencies. Thinner films reduce the time and costs associated with film deposition, while providing high electrical-thermal performance. The new material has the potential to achieve 40% heat conversion efficiency, in comparison to 10% for current materials.

Project Partners

Hi-Z Technology, Inc.
San Diego, CA

Naval Research Laboratory
Washington, DC

State University of New York
Albany, NY

University of California
San Diego, CA

Thermal and Degradation Resistant Stainless Steel for Industrial Use

A new class of stainless steel has the potential to achieve a tenfold improvement in corrosion performance and significantly improve high-pressure corrosion resistance compared to conventional stainless steel. The new material is being assessed in carburization, sulfidation, and steam environments relevant to chemical and petrochemical processing and industrial steam boilers. Improved corrosion resistance would increase plant productivity, reduce plant downtime, and achieve significant reductions in both energy intensity and greenhouse gas emissions.

Project Partners

Carpenter Technology Corporation
Northborough, MA

Oak Ridge National Laboratory
Oak Ridge, TN

Nanostructured Ferritic Alloys: Improving Manufacturing Energy Efficiency and Performance for High-Temperature Applications

Tensile and fatigue crack growth behavior of nanostructured ferritic alloys (NFAs) is being investigated for use in heavy-duty turbine wheels located in hot sections. Current wheel materials limit heavy-duty turbine operating temperatures. Currently, heavy-duty gas turbine wheels experience temperatures of approximately 1,040°F at the rim. This project seeks to increase this temperature to 1,200°F or greater to realize significant efficiency improvements. This new alloy would potentially double the lifetime of the turbine wheels, save energy in the manufacture of wheels, and allow higher-temperature operation of turbines with greater energy efficiency.

Project Partners

GE Global Research
Niskayuna, NY

New High-Temperature, Low-Cost Ceramic Media for Natural Gas Combustion Burners

Four different technologies are combined into a single radiant burner package that functions as both burner media and catalyst support for the efficient combustion of natural gas. This innovative technology seeks to replace inefficient electric and natural gas radiant heaters used in process heating throughout manufacturing, significantly reducing energy intensity and lowering NOx emissions. The burner has the potential to reduce energy consumption by 25% for part heating.

Project Partners

3M Company
Saint Paul, MN

Ultracoatings: Next-Generation Nanocoatings for High-Contact Stress Environments

Advanced thin-film coatings are being developed for high-contact stress applications. The new coatings could exhibit abrasive and erosive wear resistance up to 10 times greater than existing materials. Such coatings can enable materials for extreme operating conditions across a broad range of applications, including coal gasification, high-pressure hydraulic pumps and motors, transmission gears, and engine timing products.

Project Partners

Eaton Corporation
Southfield, MI

Borg-Warner Morse TEC
Ithaca, NY

Pratt & Whitney Rocketdyne
Canoga Park, CA

Ames Laboratory
Ames, IA

Oak Ridge National Laboratory
Oak Ridge, TN

Low-Cost Production of InGaN for Next-Generation Photovoltaic Devices

Lower-cost and low-energy-use technologies will be developed to produce photovoltaic devices based on InGaN and InAlN materials. These materials can enable the manufacture of high-efficiency photovoltaics and other products, but current processing techniques are expensive and limit the materials' commercial production. This project will develop a hydride organo-metallic vapor phase epitaxy (HOVPE), a novel deposition technique for InGaN and related materials which reduce energy costs by decreasing the time required for high-temperature, high-vacuum layer deposition processes. The HOVPE process has the potential to reduce the time required by manufacturing under high-temperature, high-vacuum processes by a factor of 100, significantly reducing energy consumption and costs.

Project Partners

Structured Materials Industries, Inc.
Piscataway, NJ

Cornell University
Ithaca, NY

Oak Ridge National Laboratory
Oak Ridge, TN

Goldeneye, Inc.
San Diego, CA

Multiphase Nanocomposite Coatings for Energy Optimization

A new generation of multi-phased, nanocomposite, ultra-hard, ultra-tough coatings are being developed for use in the dry machining and metal casting industries to reduce energy and material loss. Depending on coating compositions, the ultra-hard coatings have the potential to achieve hardness values ranging from 37 to more than 50 gigapascals (Gpa), reducing tool wear by at least 50%. The coatings are created using magnetron sputtering ion plating (MSIP) and large area filtered arc deposition (LAFAD) technologies. Processing conditions are optimized through the evaluation of the coating's microstructure, thickness, hardness, wear, friction, adhesion, stress level, and toughness.

Project Partners

UES, Inc.
Dayton, OH

Argonne National Laboratory
Argonne, IL

Triangle Precision Industries, Inc.
Kettering, OH

KAPEX Manufacturing, LLC
Troy, MI

INDUSTRIAL GREENHOUSE GAS EMISSIONS REDUCTION

Industrial greenhouse gas emissions reduction studies advance transformational technologies that can offer reductions in both carbon intensity and absolute carbon emissions for energy-intensive industries.

Next-Generation Wireless Instrumentation Integrated with Mathematical Modeling for Use in Aluminum Production

Novel instrumentation is being used to determine the electric current distribution within Hall cells, the large electrolytic cells used in primary aluminum production, to reduce greenhouse gas emissions and improve energy efficiency. These sensors use magnetic field sensing to measure, in real time, the currents in cell components, which are then communicated wirelessly. A mathematical model then evaluates the benefits of current distribution adjustments within the Hall cells. The project seeks to reduce carbon dioxide emissions from anode effects in Hall cells by 90%.

Project Partners

Wireless Industrial Technologies, Inc.
Oakland, CAJ

Alcoa
Wenatchee, WA

Removal of Volatile Organic Compounds and Organic Hazardous Air Pollutants from Industrial Waste Streams by Direct Electron Oxidation

Electron beam technologies can destroy organic pollutants in industrial waste streams and replace cost-intensive alternatives, such as conventional thermal oxidation processes. This new technology also eliminates the CO_2 emissions from thermal oxidation processes, which use large quantities of natural gas to heat pollutant-laden air. This study investigates the appropriate electron beam dose, identifies undesirable by-products, and develops a quantitative model to calculate energy and greenhouse gas emission savings.

Project Partners

Advanced Electron Beams, Inc.
Wilmington, MA

Hydrate-Free Concrete: A Low Energy, CO_2-Negative Solution

Low-temperature solidification (LTS) technology can produce hydrate-free concrete for building facades that does not require Portland cement. This technology eliminates energy consumption and CO_2 emissions associated with cement manufacture. Experiments are being performed to address uncertainties associated with the widespread usage of LTS technology, and design and performance specifications are being prepared for prototype facades and blast barriers.

Project Partners

CCS Materials, Inc.
New Brunswick, NJ

Rutgers University
New Brunswick, NJ

Crude Glycerol as Cost-Effective Fuel for Combined Heat and Power to Replace Fossil Fuels

The results of a fundamental characterization of the combustion of a wide range of crude glycerols will ultimately enable biodiesel producers to choose the most cost-effective use of their glycerol byproduct and expand the availability of the low-cost fossil fuel alternative to the industrial sector. This study will also characterize emissions and residual ash associated with combustion—two areas with little or no previous studies—to improve performance across a range of combustion environments and to enable scalability to industrial-scale applications. The project seeks to reduce energy consumption in selected industrial applications by 25%.

Project Partners

North Carolina State University
Raleigh, NC

Diversified Energy
Gilbert, AZ

Alcoa, Inc.
Pittsburgh, PA

New Silica-Alumina-Based Cementitious Material Using Coal Refuse

A new silica-alumina-based cementitious material, using coal refuse as a constituent, could replace the use of Portland cement for mine backfill, mine sealing, and waste disposal stabilization. This study produces the new silica-alumina, based on the simulation of rock formation, and develops high-performance materials using the new cementitious material as binder. A clean, low-temperature process to convert coal refuse into a desirable constituent is also being designed.

Project Partners

University of the Pacific
Stockton, CA

High Power Industrial Ultraviolet Curing Systems

This study will demonstrate the potential feasibility of replacing current, inefficient mercury lamps in industrial ultraviolet (UV)-curing applications with higher-efficiency, low-cost UV LED (light-emitting diode) systems. This study will produce a compact, modular UV LED system that features advanced, high-power packing technologies and modular optics that can be scaled up to industrial curing applications. Researchers will determine system requirements and conduct pilot testing of the UV LED curing system. The project seeks to apply technical improvements to demonstrate efficiency improvements of 30% to 50% above today's state-of-the-art UV LEDs. The results will enable the adoption of UV LED curing systems, reducing energy consumption and GHG emissions in applications that still use ovens to dry solvent-based paints, inks, and coatings.

Project Partners

SolidUV, Inc.
Chelmsford, MA

Semi Photonics, Inc.
(SemiLEDs)
Boise, ID

Armstrong, Inc.
Lancaster, 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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