Technology Commercialization Showcase 2008
Industrial Technologies Program

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Agenda

- Market Overview
- Program Objectives
- Technology Commercialization Opportunities
- Unexploited Investment Gaps

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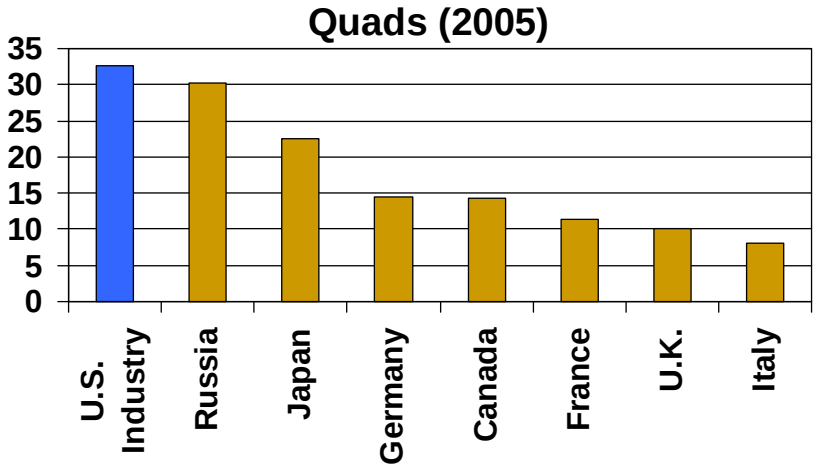
The industrial sector consumes about a third of all energy used in the United States

The U.S. industrial sector is dominated by manufacturing, which

- Makes highest contribution to GDP (12%)
- Produces nearly quarter of world manufacturing output
- Spent $104 billion in 2006 on energy purchases
- Supplies >60% of US exports, worth $50 billion/month
- Employs nearly 14 million people
- Spurs job creation and investment in other sectors

Sources: National Association of Manufacturers, *Importance of Manufacturing overview;* Energy Information Administration, Department of Commerce

The U.S. industrial sector consumes more energy than any other G-8 nation



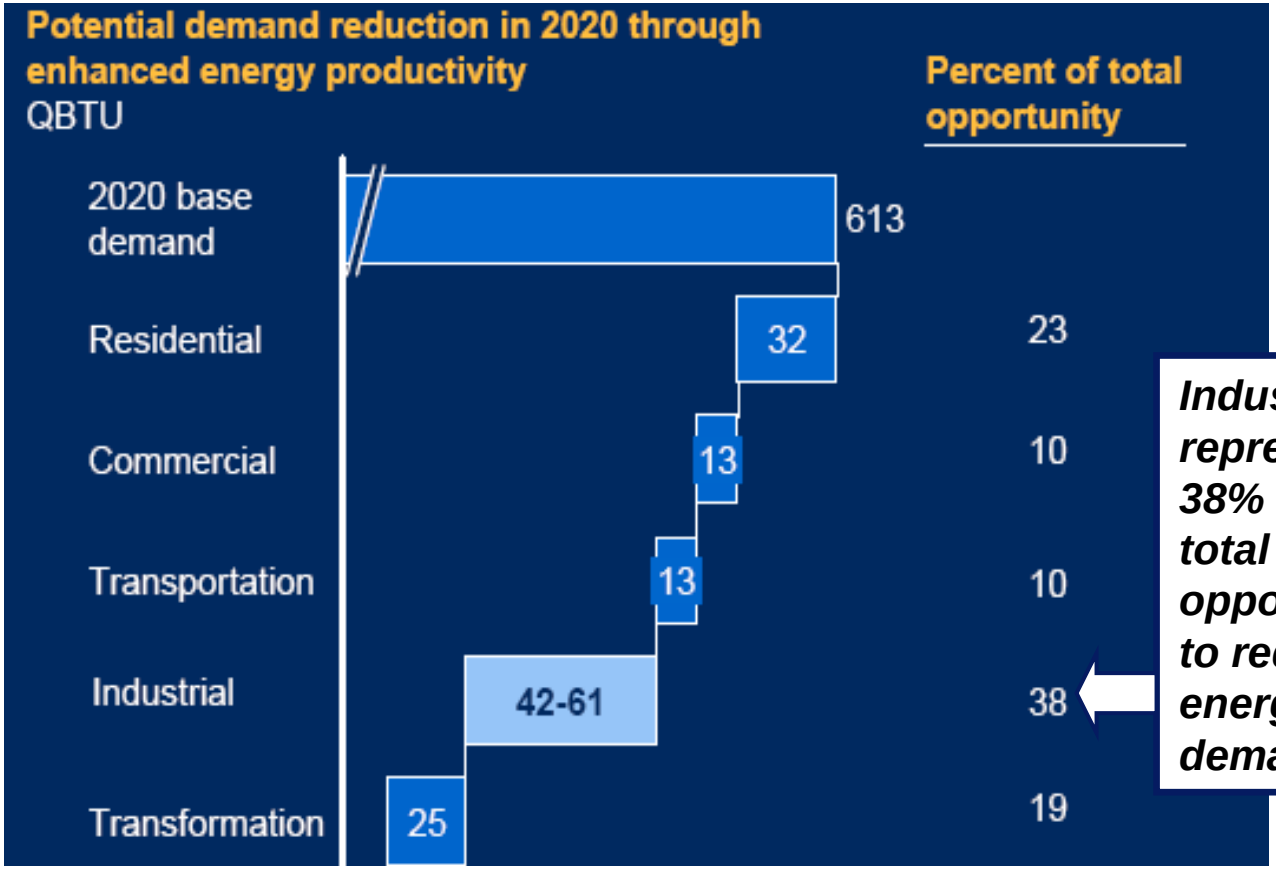
Source: EIA, International Energy Outlook 2008

The U.S. industrial sector is the most diverse in energy services required and mix of energy sources

Petroleum	38.1%
Natural Gas	33.3%
Electricity*	13.5%
Coal and Coke	8.5%
Renewable Energy	6.6%

* Excludes losses

Studies show that the industrial sector presents the biggest opportunity to increase energy efficiency worldwide



Source: McKinsey & Company, 2007.

Industrial energy efficiency is possibly the quickest and most reliable way to reduce future carbon emissions in the United States.

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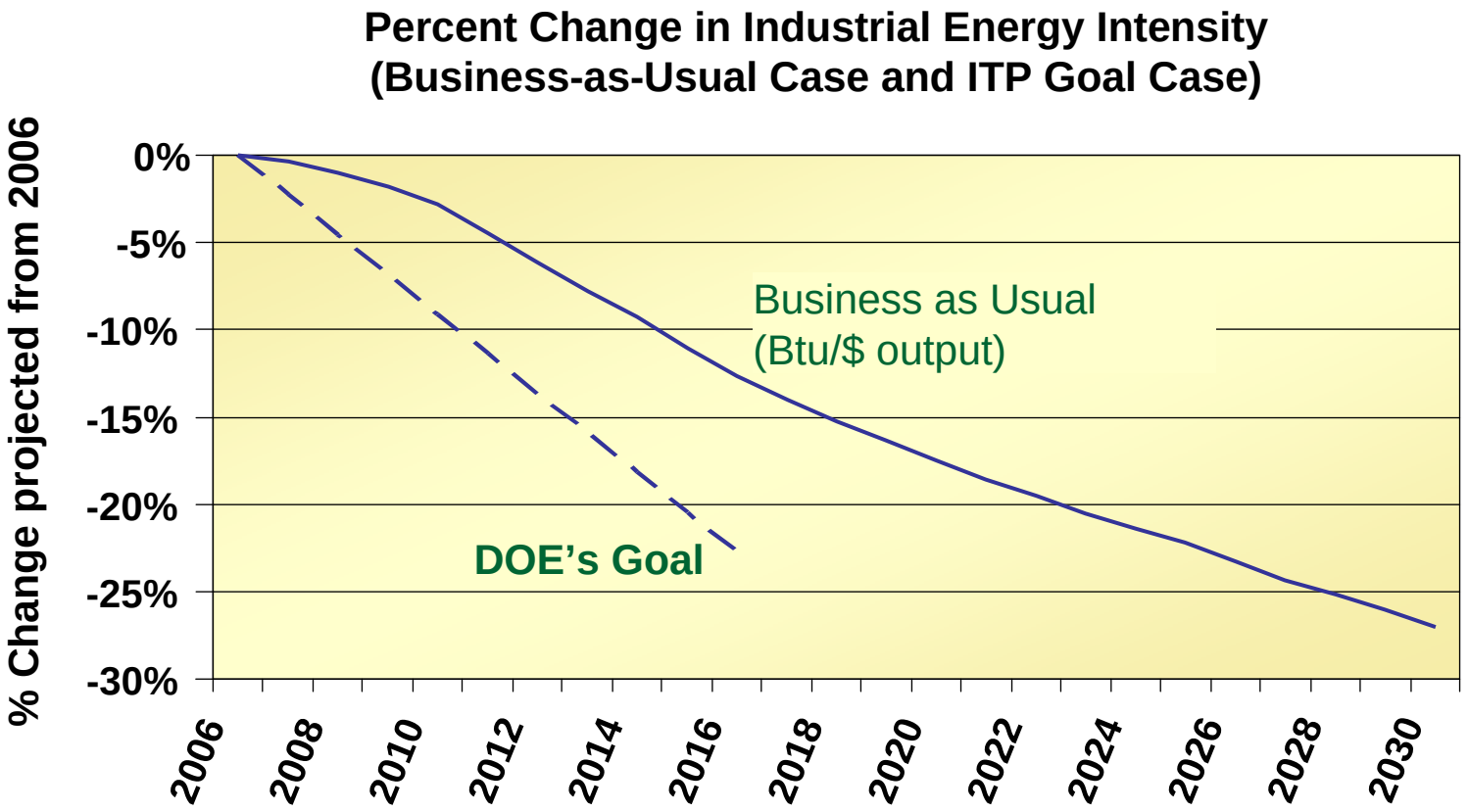
DOE seeks to support the U.S. industrial sector to achieve 25% reduction in energy intensity by 2017 (EPAct 2005)



Source: EIA, AEO 2007, Business As Usual (BAU) case

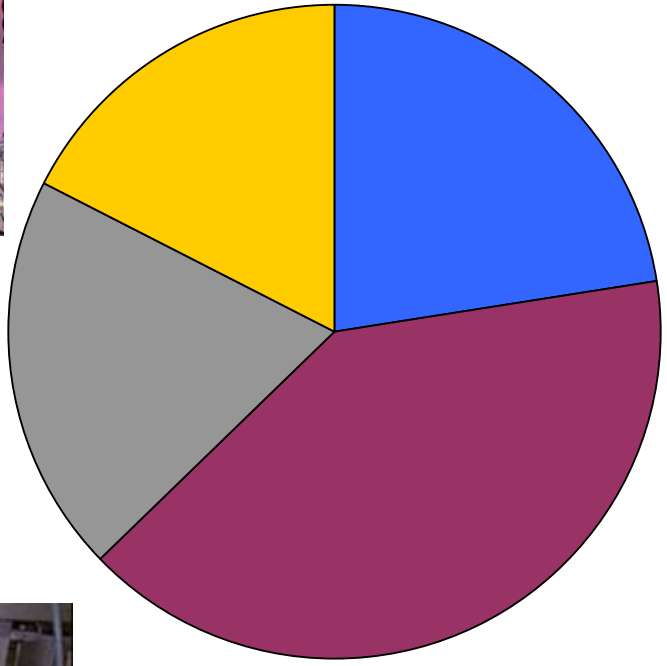
DOE/ITP invests in major energy-saving opportunity areas

17% Industry-Specific

R&D addressing top priorities in America's most energy-intensive industries such as chemicals, steel, and forest products

23% Distributed Energy

Activities to spur widespread commercial use of CHP and other distributed generation solutions



20% Technical Assistance

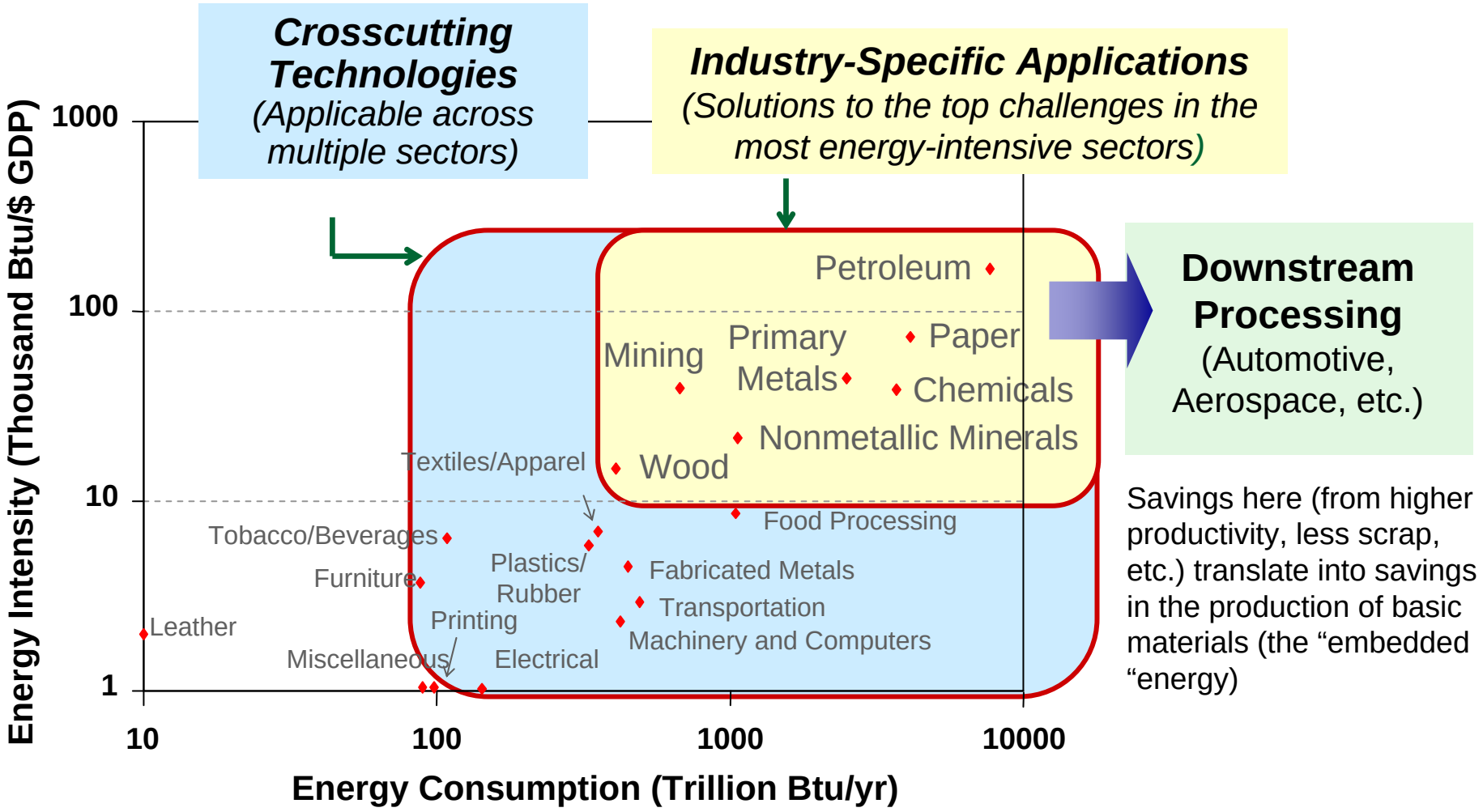
Help plants save energy today energy using management practices and efficient new technologies

40% Crosscutting

R&D to develop technologies applicable to multiple subsectors

Total FY08 Funding
$64 million

DOE/ITP focuses on the most energy-intensive sectors while serving needs of the broader industrial base



Savings here (from higher productivity, less scrap, etc.) translate into savings in the production of basic materials (the "embedded "energy)

Sources: Energy Information Administration, Department of Commerce

DOE/ITP pursues a cross-cutting, manufacturing technology platform based R&D portfolio strategy

Reactions & Separations

- Advanced Water Removal
- Advanced Gas Separations
- Hybrid Distillation
- Energy-Intensive Conversion Processes

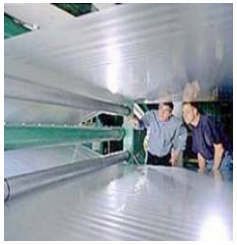
High-Temperature Processing

- Lower-Energy Materials Processing
- New Materials Development
- Materials Processing for Emerging Industries

Waste Heat Recovery

- Super Boiler
- Ultra-High Efficiency Furnace
- Waste Heat Recovery Systems

Sustainable Manufacturing



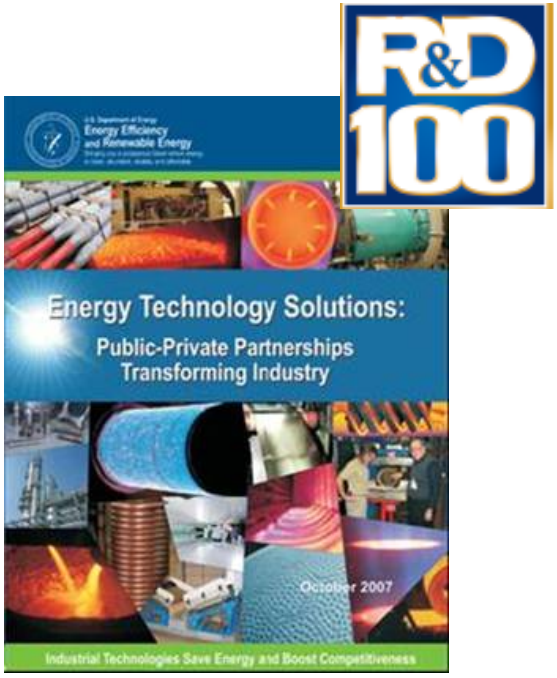
- Net Design and Manufacturing
- Engineered Materials and Coatings
- Advanced Forming, Joining, and Assembly
- Integrated Manufacturing and Energy-Efficient Material Handling and Plant Operations

- Addressing the top energy saving opportunities across industry sectors
- Applying a stage-gate investment decision model for DOE investment
- Partnering with industry to validate market requirements

DOE/ITP has a proven track-record of delivering results

Together with industry, we have successfully developed and moved cutting-edge technologies and energy-saving measures into practice

- Over 170 technologies have entered commercial markets
- 42 R&D 100 awards between 1991 and 2007
- 156 patents between 1994 and 2005
- Over 16,000 plants impacted by our energy savings tools and assistance
  - 5 quads of energy savings
  - 86 MMTCe reduction



Agenda

- Industry Landscape
- Program Objectives
- Technology Commercialization Opportunities
- Unexploited Investment Gaps

Technology Commercialization Opportunities

Technology	Lead Organization
Materials for High-Temperature, High-Alkali Environments	Oak Ridge National Lab
Multiport Cylinder Dryer for Retrofit and New Installations	Argonne National Lab
Advanced Membrane Separation Technologies for Energy Recovery from Industrial Process Streams	Oak Ridge National Lab
Novel Membrane Technology for Green Ethylene Production	Argonne National Lab
Catalyst Manufacturing by Atomic Layer Deposition	Argonne National Lab
Solid State Consolidation, Fabrication, and Joining of Low-Cost Titanium for Industrial Application	Oak Ridge National Lab
Pulse Thermal Processing of Nanoparticle Photovoltaic Materials	Oak Ridge National Lab
Energy Efficient Natural Gas Liquid Removal Process for Low-Cost Chemical Feedstocks	Gas Technology Institute
Isothermal Melting Process for Aluminum	Apogee Technology, Inc.
Ultrananocrystalline Diamond Pump Seals	Advanced Diamond Technologies, Inc.
High Octane Fuel via Catalytic Distillation	Exelus, Inc.
Drill-String Radar Navigation for Horizontal Directional Drilling	Stolar Research Corp.
Low Temperature Plasma Technology for Controlling VOC Emissions	Drexel University
Distillation Column Flooding Predictor	2ndpoint, LLC
Waste-Heat Powered Ammonia-Absorption Refrigeration	Energy Concepts Company

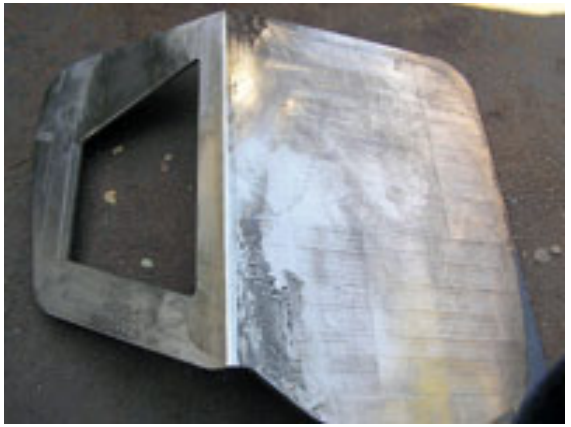
Solid State Consolidation, Fabrication, and Joining of Low-Cost Titanium for Industrial Application

Description

New titanium (Ti) powder production processes feature a non-melt approach, which reduces energy requirements and wasted material. The new process could decrease the cost of titanium from $40-50/lb to $5-$8/lb.

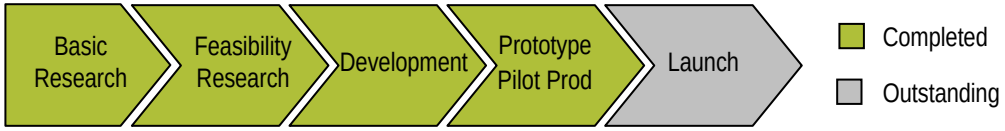
Impact

- Improves cost efficiency by over 50%
- Replaces milling and melting high costs
- Reduces the amount of scrap and allows for new alloys and engineered composites



Titanium door

Technology Readiness



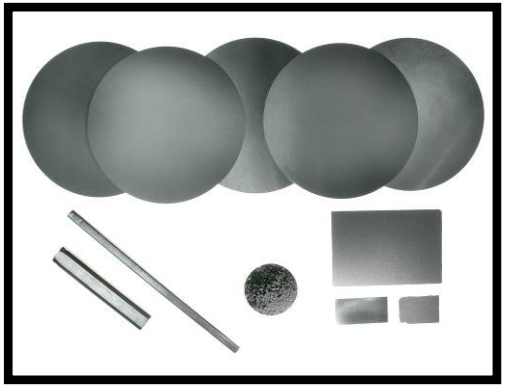
Estimated Time to Market

- 2-3 years

Technology Developer: **Oak Ridge National Laboratory**

Solid State Consolidation, Fabrication, and Joining of Low-Cost Titanium for Industrial Application

- PROBLEM: Application of titanium is limited by high cost and extremely long production lead times during conventional processing.
- DESCRIPTION OF INVENTION/TECHNOLOGY: Solid-state (non-melt) consolidation, fabrication, and joining technologies of Ti powders are being developed to produce low -cost sheet, plate, and near-net-shape complex geometric components for industrial applications.
- IMPACT: Efficiencies in solid-state consolidation of powders could reduce the financial and energy cost of production of Ti products by greater than 50%, resulting in consolidated Ti plate at $9-$10/lb.
  - Market: Over 70,000 metric tons per year worldwide. Titanium production projected to triple by 2015, with 50% of growth in industrial applications.
- IP POSITION: ORNL has a patent on Direct Fabrication of Titanium Sheet. Technology is available for licensing.
- TECHNOLOGY STATUS: ORNL has demonstrated the feasibility of solid state consolidation of low cost titanium powders with wrought properties.
  - Further development of solid state consolidation Is required to bring low-cost titanium to industry, realize energy savings, and penetrate new markets.



Low-Cost Titanium and Ti Alloy Plate, Bar, and Sheet Produced at ORNL

Technology Developer: **Oak Ridge National Laboratory**

Materials for High-Temperature, High-Alkali Environments

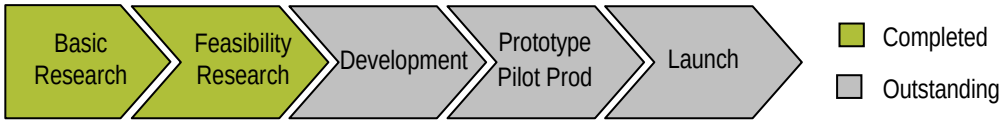
Description

New refractory materials for furnaces and process vessels withstand high-temperature, high-alkaline industrial environments

Impact

- Materials will have 2x life span and/or 20% higher thermal efficiency than current materials
  - Improves furnace productivity and reliability
  - Reduces maintenance requirements
  - Reduces heat losses

Technology Readiness



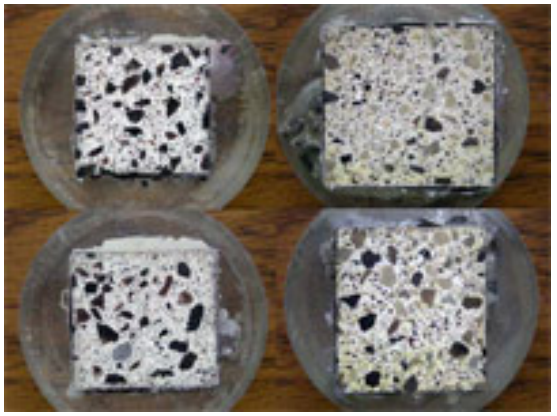
Estimated Time to Market

- 3-5 years

Technology Developer: Oak Ridge National Laboratory

Materials for High-Temperature, High-Alkali Environments

- PROBLEM: Conventional refractory materials have limited performance in harsh environments and are costly to install and repair. Maintenance downtime is significant and reduce productivity.
- DESCRIPTION OF INVENTION/TECHNOLOGY: A new family of magnesia/alumina materials for refractory environments will be produced using new aggregate materials, bond systems, protective coatings, and phase formation techniques.
- IMPACT: Longer life and better performance. Applicable to aluminum, chemical, forest products, glass, and steel industries.
- IP POSITION: None
- TECHNOLOGY STATUS:
  - Estimated completion: 2-3 years
  - Project partner MINTEQ will produce the materials and introduce them to the market place by their standard commercialization means
  - Results of successful applications will be presented at academic and industrial meetings to open up additional sites for in-plant trials and technology application at other related industrial sites and in industries not currently targeted



Technology Developer: **Oak Ridge National Laboratory**

Multiport Cylinder Dryer for Retrofit and New Installations

Description

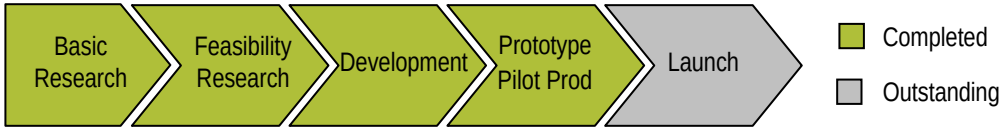
Multiport dryer technology improves paper drying through a radically different steam-flow design.

Impact

- Dryer production rates boosted 20-50% relative to conventional dryers
- Energy costs lowered through reduced steam pressures
- New flexibility with respect to paper/cardboard thickness
- Potential application for up to 30,000 U.S. paper dryers

Multiport Dryer half-shell showing internal dryer insert.

Technology Readiness



Estimated Time to Market

2-3 years

Estimated Commercialization Cost

$10,000 - $15,000 per insert based on a full-scale demonstration unit

Technology Developer: Argonne National Laboratory

Multiport Cylinder Dryer for Retrofit and New Installations

- PROBLEM: Current paper drying technology is relatively inefficient and capital-intensive.
- DESCRIPTION OF INVENTION/TECHNOLOGY: This technology can be retrofit into full-sized dryers, significantly minimizing the thickness of the condensate layer and increasing the surface temperature of the dryer shell.
- IMPACT: Retrofit of multiport dryer inserts provides 20-50% increases in productivity of existing equipment.
  - For installations in new plants, multiports reduce the numbers of dryers required per application, reducing capital expenses
  - The savings from reduced capital investment (e.g. fewer drums) would increase ROI on the conventional drying line by up to 7%
- IP POSITION: Argonne received a patent for this technology in 2002 and the technology is available for licensing.
  - Market: Up to 30,000 paper dryers in the USA
  - The technology is potentially applicable to any rotary surface dryer application (e.g., paper, plastics, food processing)
- TECHNOLOGY STATUS: The technology underwent full-scale testing at a commercial facility and is currently being re-evaluated and possibly re-engineered.

Multiport Dryer insert installed in a full-scale steam dryer

R&D 100 award winner in 2005.

Technology Developer: **Argonne National Laboratory**

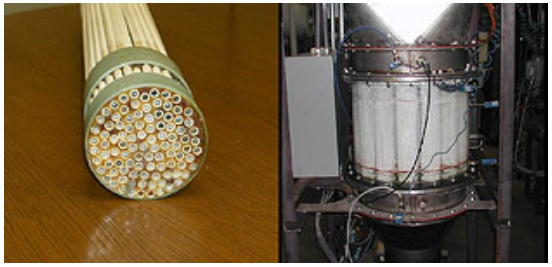
Advanced Membrane Separation Technologies for Energy Recovery from Industrial Process Streams

Description

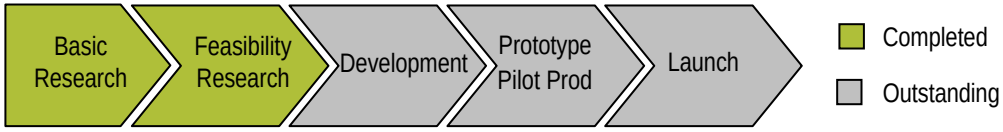
A novel transport membrane condenser (TMC) efficiently recovers energy from process exit gases.

Impact

- Improved robustness, thermal conductivity, and resistance to corrosion
- Enables energy recovery from relatively low-temperature waste streams
- Energy savings potential of about 125 trillion Btu/yr by 2030



Technology Readiness



Estimated Time to Market

- 1-2 years for small- to medium-sized boilers (80,000 unit market)
- 3-4 years: large industrial watertube boilers (6,000 unit market)
- 5-6 years: paper and steel industries (2,000 unit market for paper)

Technology Developer: **Oak Ridge National Laboratory**

Advanced Membrane Separation Technologies for Energy Recovery from Industrial Process Streams

- PROBLEM: Energy recovery from low-temperature waste streams is not effective at large scales. Commercially available condensers have payback periods of at least 2-3 years.
- DESCRIPTION OF INVENTION/TECHNOLOGY: New transport membrane condenser (TMC) improves energy recovery from industrial exit gas streams. TMC was successfully tested on clean gas streams; new robust membranes will enable more widespread application.
- IMPACT:
  - Market: Major markets include the chemical, forest products, and petroleum industries. Up to 80,000 medium size boilers; 6,000 watertube boilers; and 2,000 wood-bark-fired boilers
  - Potential savings: 125 trillion Btu/yr are projected by 2030
- IP POSITION: No patents
- TECHNOLOGY STATUS: At least two candidate materials with adequate heat transfer, durability, and corrosion resistance have been identified. Prototypes will be tested in industrial environments and evaluated for commercialization potential.

Full-size TMC module undergoing flue gas testing

Technology Developer: **Oak Ridge National Laboratory**

Novel Membrane Technology for Green Ethylene Production

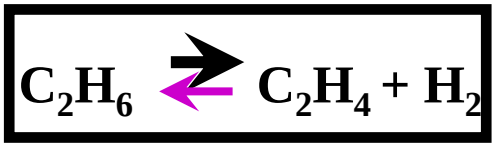
Description

Hydrogen transport membrane increases ethylene production and reduces emissions by improving conversion rate to 74%.

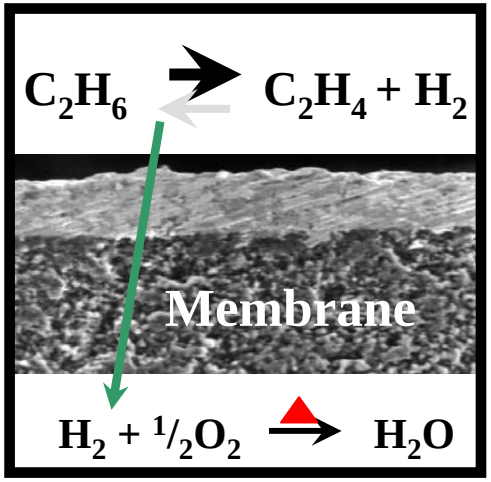
Impact

- Reduced feedstock requirements
- Fewer process steps
- Potential for >12% reduction in operating and capital costs
- No CO_2, CO or NOx emissions produced

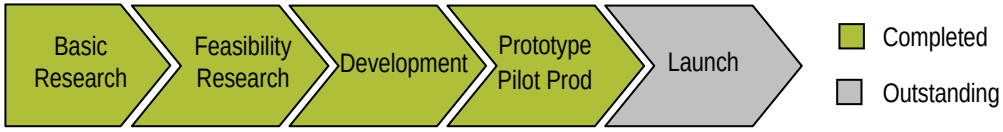
Traditional Production limited by reverse reaction



Membrane Process changes reaction, adds heat



Technology Readiness



Estimated Time to Market

3-5 years

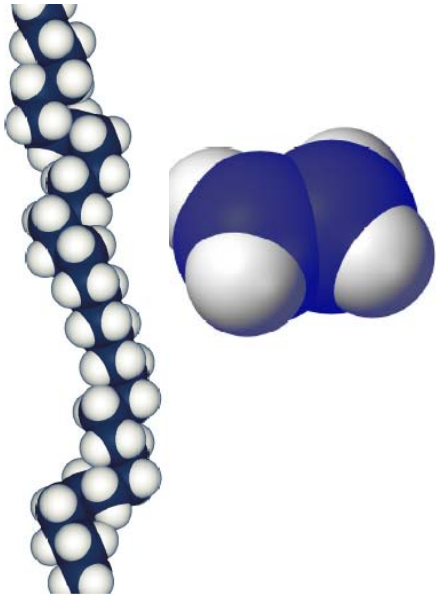
Estimated Commercialization Cost

Capital Needs - Significant capital costs (>$10MM est.) required to modify/change furnace design

Technology Developer: **Argonne National Laboratory**

Novel Membrane Technology for Green Ethylene Production

- PROBLEM: Feedstock conversion is thermodynamically limited to ~65%. Downstream separation/purification and recovery of byproducts is energy- intensive and accounts for ~70% of the capital costs.
- DESCRIPTION OF INVENTION/TECHNOLOGY: Hydrogen transport membrane increases the conversion rate to 74% by selectively removing hydrogen and recovering the hydrogen energy. The ethane stream is prevented from reacting with the atmosphere, eliminating CO_2, CO, and NOx emissions.
- IMPACT: Lower feedstock and energy use, reducing operational and capital costs by >12%.
  - Market: Ethylene is a $**22 Billion/year** industry in this country.
- IP POSITION: Argonne has a patent on membrane materials and a patent application on this novel process. Technology is available for licensing.
- TECHNOLOGY STATUS: Proof-of-concept has been demonstrated. Project team now seeking a commercialization partner to produce the membrane cost-effectively.
  - Commercialization for the U.S. market will require process design, engineering, and cost analysis for full-scale operations, fabrication, and demonstration at the pilot scale.



Ethylene is the most produced organic compound in the world

Technology Developer: **Argonne National Laboratory**

Catalyst Manufacturing by Atomic Layer Deposition

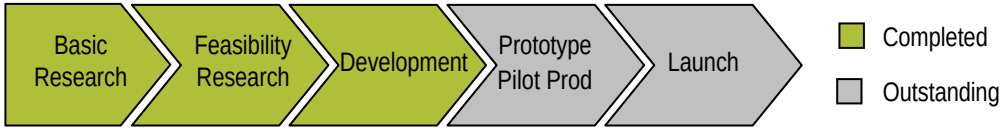
Description

Atomic layer deposition (ALD) provides precise control over composition and morphology of catalysts used in chemical production.

Impact

65-75% improvement in conversion rates, lowering energy requirements for bulk organic chemicals production

Technology Readiness



"The world catalyst market will reach $12.3 billion in 2010, driven by growing demand in the chemical, polymer and refining industries for more energy efficient processes and products."

Freedonia Group

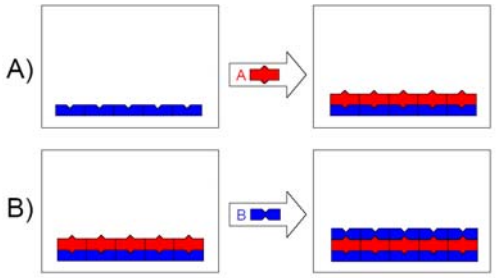
Estimated Time to Market

3-5 years (est.) to prepare for full implementation into the catalyst market

Estimated Commercialization Cost

Capital Needs – ALD catalyst will retrofit into existing facilities with minor equipment changes

Atomic Layer Deposition (ALD)
precise surface control

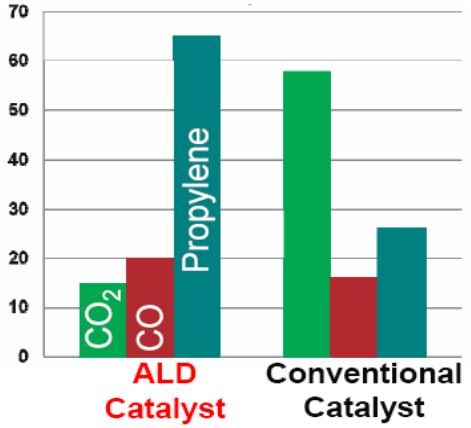


Technology Developer: **Argonne National Laboratory**

Catalyst Manufacturing by Atomic Layer Deposition

- PROBLEM: Thermal production of chemicals is cost- and energy-intensive. Catalytic production methods to date have not been viable.
- DESCRIPTION OF INVENTION/TECHNOLOGY: Atomic layer deposition (ALD) provides precise control over production of catalysts. The improved catalysts represent a viable alternative thermal production of chemicals.
- IMPACT: 65-75% improvement in chemical conversion rates. ALD technology is currently used for mass production of Dynamic Random Access Memory (DRAM) chips. Other potential uses are:
  - Fuel cells and for transportation fuels and hydrogen production
  - Solid state lighting ($4 billion for high-brightness LEDS in 2007)
  - Solar cells ($7.6 billion 2004)
  - Superconducting radio-frequency (SCRF) cavities for international linear collider ($3 billion for cavities)
  - Membranes for separations ($2.4 billion in U.S. 2006)
- IP POSITION: Argonne has two patent applications and one invention disclosure. Additional patent applications on ALD technology. Technology available for licensing.
- TECHNOLOGY STATUS: Argonne has demonstrated superior performance at bench scale. Scale-up of catalyst manufacturing is in progress.

Atomic Layer Deposition (ALD) precise control



ALD catalyst makes more propylene

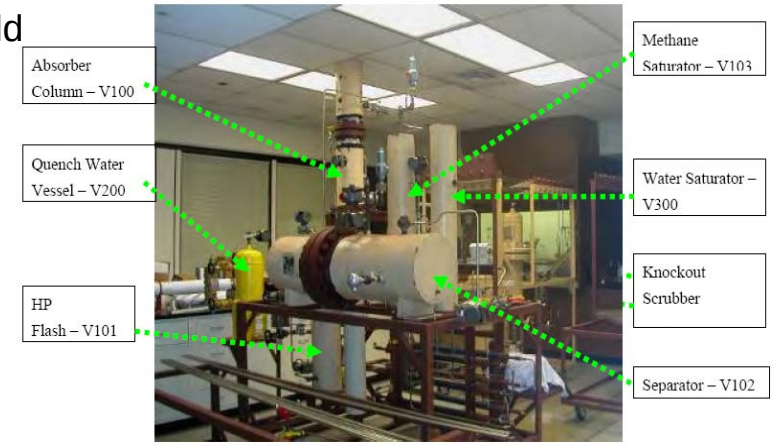
ALD produces 2.4 times more propylene

Technology Developer: **Argonne National Laboratory**

Energy Efficient Natural Gas Liquid (NGL) Removal Process for Low-Cost Chemical Feedstocks

Description

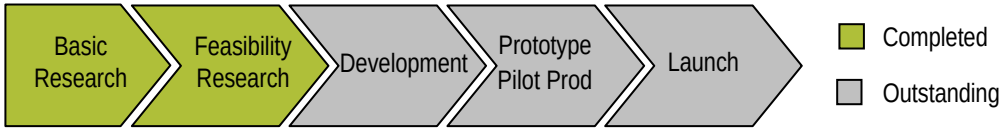
A new Natural Gas Liquid (NGL) recovery process will increase the availability of NGL to be separated and resold as valuable chemical feedstocks



Impact

- Reduces cost of NGL recovery from natural gas
- Improves energy efficiency of NGL recovery
- Potential energy savings of 200 trillion Btu

Technology Readiness



Estimated Time to Market

4-5 years

Project Leads

Gas Technology Institute & Oak Ridge National Laboratory

Technology Developer: Gas Technology Institute

Energy Efficient Natural Gas Liquid (NGL) Removal Process for Low-Cost Chemical Feedstocks

- PROBLEM: Conventional Natural Gas Liquid (NGL) recovery technologies, are highly energy-intensive and expensive to operate, requiring low refrigeration temperatures and substantial energy to recompress the processed gas.
- DESCRIPTION OF INVENTION/TECHNOLOGY: A new low-cost, energy-efficient NGL recovery process integrates the dehydration of the raw natural gas steam and the removal of NGLs to maximize heat recovery. Equipment costs are reduced.
- IMPACT:
  - Market: The U.S. is the largest NGL producer in the world, with a production capacity of 1.9 million barrels per day (bpd) in 2002, and a value of over $10 billion at the average spot market price.
  - Potential savings: up to 200 trillion Btu/yr
- IP POSITION: The US Patent Office sent a notice on the publication of a new patent application in January, 2008.
- TECHNOLOGY STATUS: The bench scale unit is being commissioned for initial testing. Researchers are identifying a strategy for fabricating and operating a pilot plant unit.

Technology Developer: **Gas Technology Institute**

Pulse Thermal Processing (PTP) of Nanoparticle Photovoltaic Materials

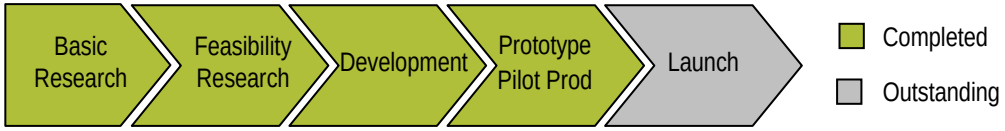
Description

CIGS nanoparticles can be fabricated and screen-printed on inexpensive low-temperature polymer substrates and “flashed” using PTP technology, achieving ultimate control of composition and performance over large areas.

Impact

Applications include photovoltaic materials, thin-film transistors for flat panel displays, thin-film batteries, LED’s for solid state lighting, printed integrated circuits such as Radio Frequency ID tags.

Technology Readiness

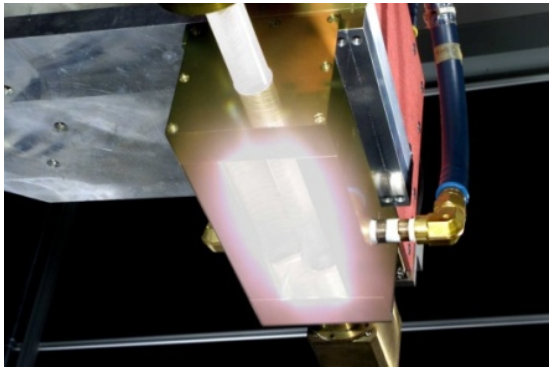


Estimated Time to Market

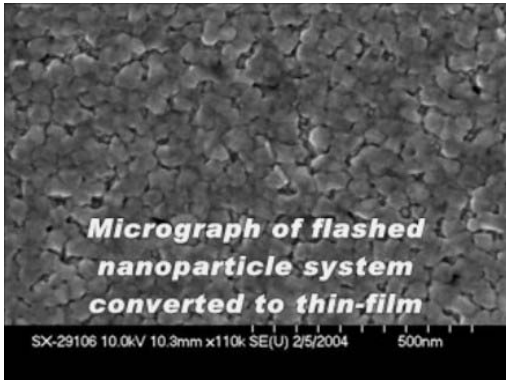
2-3 years

Project Lead

Oak Ridge National Laboratory



High Density Plasma Arc-Based Technology

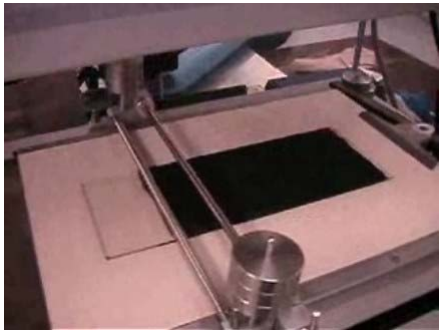


0.001 second flash from PTP

Technology Developer: **Oak Ridge National Laboratory**

Pulse Thermal Processing (PTP) of Nanoparticle Photovoltaic Materials

- PROBLEM: Thin-film PV material systems, such as copper-indium-gallium-diselenide (CIGS) are too costly and difficult to make over large areas using vacuum deposition methods.
- DESCRIPTION OF INVENTION/TECHNOLOGY: A new method of producing nanoparticle photovoltaic materials
  - Short processing times leading to high throughput with low-cost polymer substrates
  - Large area compositional control, resulting in high performance
- IMPACT:
  - Goal is to approach solar cell performance observed at lab-scale (19.2 % efficiency) at the full-scale module level. Solar cell efficiencies of 9% are currently the standard.
  - PV Market: growing at 30% to 40% per year and will be a $15 billion market worldwide by 2020
- IP POSITION: ORNL has a patent on Pulse Thermal Processing. Technology is available for licensing.
- TECHNOLOGY STATUS: Proof-of-principle experiments have been performed at ORNL on a multitude of technology areas.
  - Technology is available as a prototype rather than an off-the-shelf format
  - Capital Needs: CIGS nanoparticle fabrication and dispersion ink, screen printer, high density plasma arc lamp



Low cost screen printing

Flexible PV

Technology Developer: **Oak Ridge National Laboratory**

Isothermal Melting Process for Aluminum

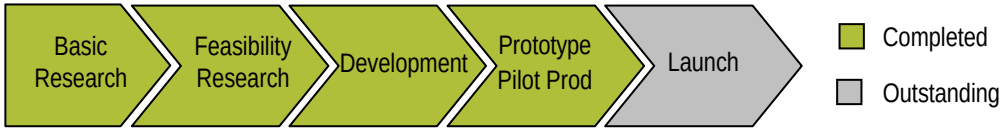
Description

A new aluminum melting process uses immersion heaters to supply melting energy via conduction rather than by radiant heating

Impact

- Eliminates in-plant emissions
- Reduces metal losses to oxidation from 2-4% to less than 1%
- Uses about 30% of energy input compared with conventional gas-fired melters
- 97% melting efficiency

Technology Readiness



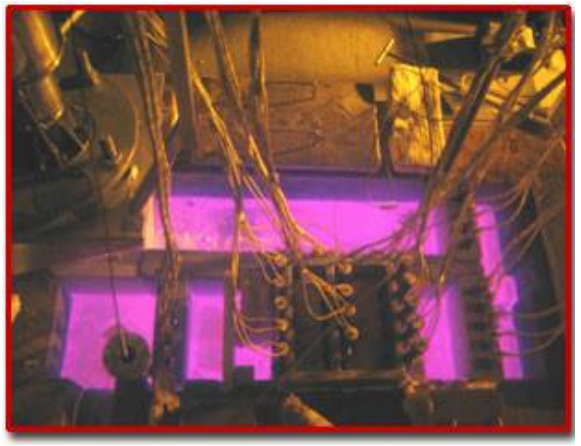
Estimated Time to Market

2-3 years

Technology Developer: Apogee Technology, Incorporated

Isothermal Melting Process for Aluminum

- PROBLEM: Conventional radiant heating requires extremely high temperatures, and energy losses can be high.
- DESCRIPTION OF INVENTION/TECHNOLOGY: Immersion heaters supply melting energy with 97% efficiency via conduction to enhance the efficiency of aluminum melting, alloying, and purification. The system allows molten metal to be recycled into the molten pool at the same temperature from which it was withdrawn
- IMPACT: Isothermal Melting uses 25-30% of the in-plant energy and occupies 25% of the floor-space.
  - Potential Savings: If implemented across the domestic aluminum industry, the process could save 62 trillion Btu/yr.
- IP POSITION: Over 30 patents obtained
- TECHNOLOGY STATUS:
  - Commercial-scale melter installed and operated at Aleris International facility in 2005, with maximum melt rate of 7,000 lb/hr
  - Apogee currently developing over-the-road heated delivery and in-plant dispensation technology to extend ITM's capabilities and eliminate in-plant holding furnaces.
  - R&D 100 Award Winner, 2006

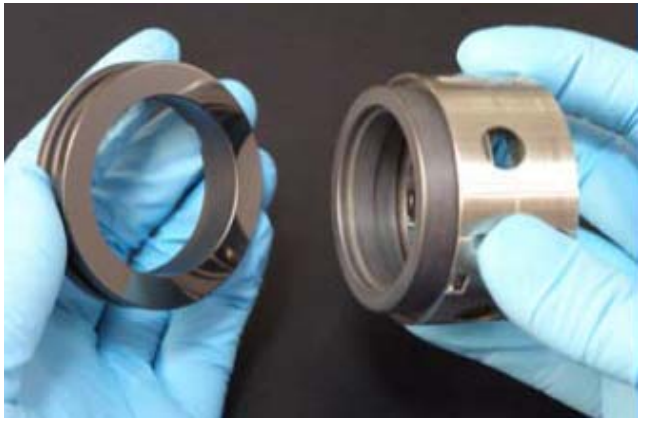


Technology Developer: Apogee Technology, Incorporated

Ultrananocrystalline Diamond (UNCD®) Pump Seals

Description

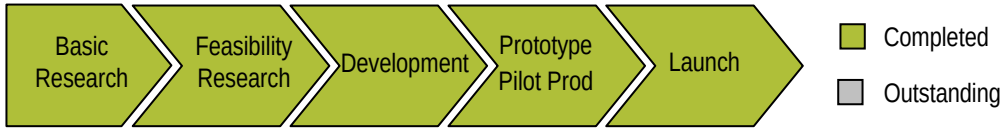
Ultrananocrystalline Diamond (UNCD®) offers a unique diamond thin-film microstructure that provides superior low-friction, corrosion- and wear-resistance when used in mechanical seal applications.



Impact

- Reduces pump shaft frictional torque ~75%
- Optimizes pump seals and a range of mechanical systems
- Applicable to multiple industries

Technology Readiness



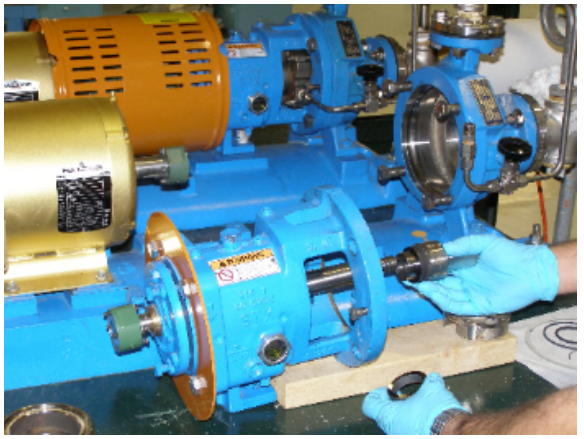
Estimated Time to Market

Available for licensing

Technology Developer: Advanced Diamond Technologies, Inc.

Ultrananocrystalline Diamond (UNCD®) Pump Seals

- PROBLEM: The durability of diamonds makes them an attractive pump seal material, but their high cost limits their commercial application
- DESCRIPTION OF INVENTION/TECHNOLOGY: A new breakthrough growth process produces an ultrananocrystaline diamond thin film for use as a mechanical seal surface material. This process enables the use of diamond as an industrial and electronic material.
- IMPACT: UNCD® improves reliability, saves energy, and reduces costs in fluid pumping systems with the exceptional hardness and low friction attributes of smooth nanocrustalline diamond.
- IP POSITION: No patents issued
- TECHNOLOGY STATUS:
  - Technology has been successfully demonstrated at a large scale
  - Advanced Diamond Technologies Inc. was established to accelerate technology transfer and commercialization of UNCD in industry
  - R&D 100 Award Winner, 2008 and 2003



Technology Developer: Advanced Diamond Technologies, Inc.

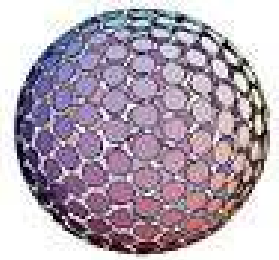
High Octane Fuel via Catalytic Distillation

Description

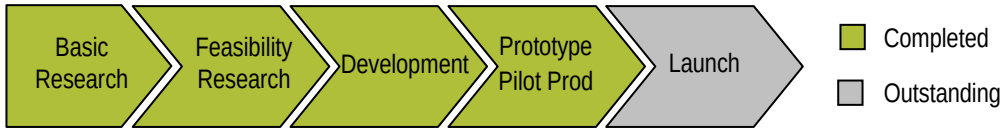
ExSact is an environmentally benign process that produces a high-octane gasoline blend-stock (alkylate) to meet the rising demand for cleaner burning transportation fuels.

Impact

- Environmentally friendly alternative to conventional alkylation processes
- Reduces capital and operating expenses compared with conventional technology
- Can be retrofit to existing refineries



Technology Readiness



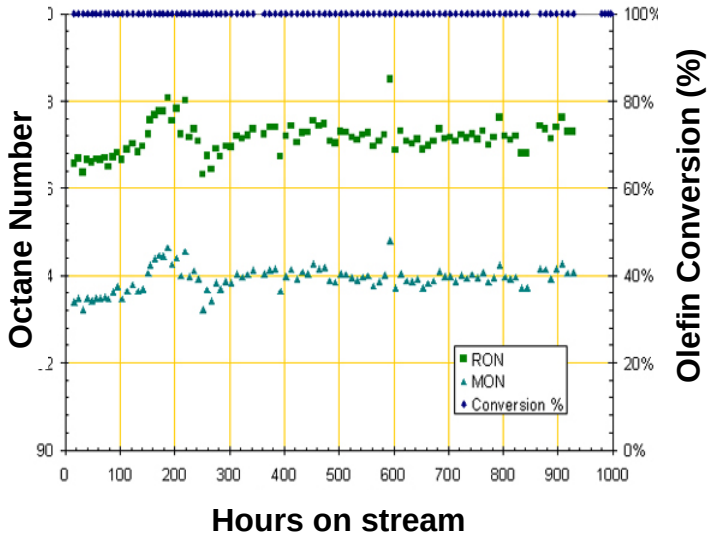
Estimated Time to Market

2-4 years

Technology Developer: Exelus, Inc.

High Octane Fuel via Catalytic Distillation

- PROBLEM: High octane alkylate, an ideal clean fuel component for reformulated gasoline, is currently made using toxic liquid acid catalysts such as hydrofluoric or sulfuric acid.
- DESCRIPTION OF INVENTION/TECHNOLOGY: The pilot-tested process ExSact uses benign, solid-acid catalysts coupled with an innovative reactor to produce high-octane alkylate.
- IMPACT:
  - Lowers utility consumption and produces fewer by-products compared to existing technologies
  - Complete elimination of refrigeration and sulfuric acid regeneration and simple reactor construction reduces capital costs
- IP POSITION: No patents issued
- TECHNOLOGY STATUS:
  - Performance has been validated for over 1,000 hours of pilot-plant operation
  - Currently being designed to revamp a 3,500 bpd oligomerization unit



Technology Developer: **Exelus, Inc.**

Drill-String Radar Navigation (DSR) for Horizontal Directional Drilling

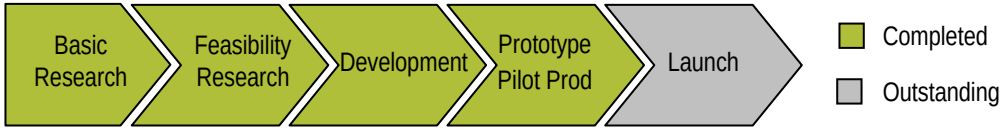
Description

DSR is a radiowave-based radar that identifies coal-rock boundaries to guide horizontal drilling in coal seams.

Impact

- Withstands drilling vibration, unlike conventional sensors
- Enables real-time control to avoid costly trial-and-error drilling and sidetracking
- Reduces energy, risk, cost, and time required for horizontal drilling

Technology Readiness



Estimated Time to Market

2-4 years

Technology Developer: Stolar Research Corporation

Drill-String Radar Navigation (DSR) for Horizontal Directional Drilling

- PROBLEM: The difficulty of mapping and documenting mines forces miners to drill hundreds of boreholes in order to pinpoint the location of old mines, coal beds, or oil reservoirs.
- DESCRIPTION OF INVENTION/TECHNOLOGY: DSR uses electromagnetic waves to detect and range rock boundaries and estimate the orientation of fractures and bedding plains, coal, and sandstone.
  - Can be used for detection, navigation and mapping through unknown strata
  - Is a necessary tool for advanced measure-while-drilling (MWD) and log-while-drilling (LWD) applications
- IMPACT: DSR improves mining efficiency, allowing measurement while drilling and identifying coal seam thickness with high accuracy.
  - Reduces the cost of long-hole drilling by avoiding trial-and-error drilling
  - Reduces risk of mining into significant geographic anomalies.
- IP POSITION: no patents issued
- TECHNOLOGY STATUS:
  - Finalizing testing
  - R&D 100 Award winner, 2005

Technology Developer: Stolar Research Corporation

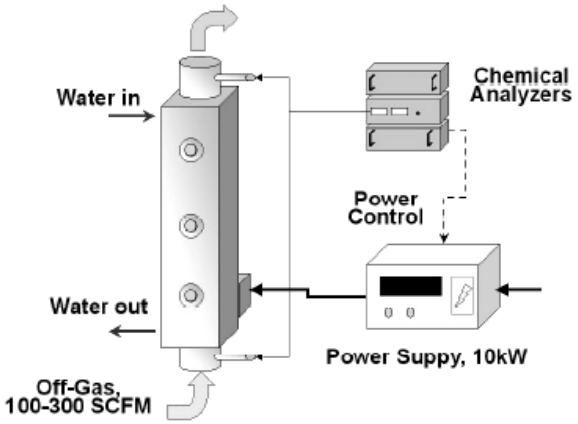
Low Temperature Plasma Technology for Controlling VOC Emissions

Description

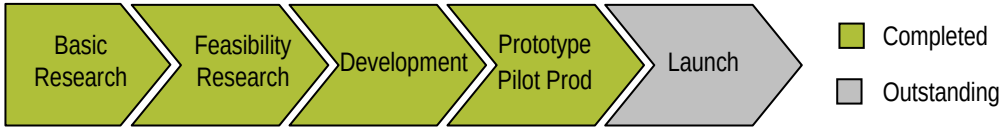
New technology uses non-thermal plasmas that can selectively destroy volatile organic compounds (VOCs).

Impact

- Reduces VOC emissions in pulp mills and wood products plants
- Avoids unnecessary and wasteful heating of an entire in-mill slipstream
- Lower capital costs compared to present-day control technology (regenerative thermal oxidizers)



Technology Readiness



Estimated Time to Market

2-4 years

Technology Developer: Drexel University

Low Temperature Plasma Technology for Controlling VOC Emissions

- PROBLEM: Conventional VOC control technologies, such as regenerative thermal oxidizers (RTO), are energy-intensive and depend on combustion technologies to heat an entire waste stream
- DESCRIPTION OF INVENTION/TECHNOLOGY: Non-thermal plasmas produce excited free radicals and ions to selectively destroy VOCs.
- IMPACT:
  - Requires less energy to operate compared with conventional emissions control technology
  - In addition to VOCs, the technology also avoids CO_2 production
- IP POSITION: 2 patents issued
- TECHNOLOGY STATUS:
  - Technology has been demonstrated at a Georgia-Pacific Corporation mill and is undergoing further testing.

Technology Developer: Drexel University

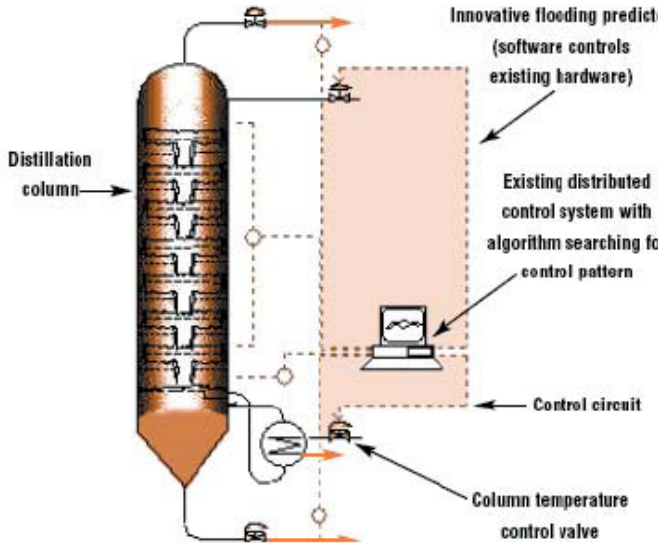
Distillation Column Flooding Predictor™

Description

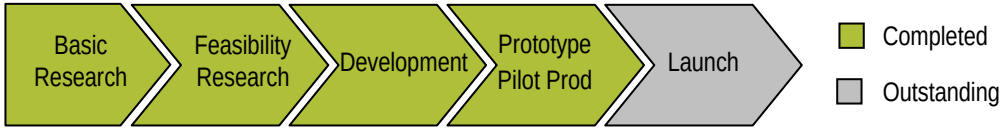
Flooding Predictor™ is an advanced process-control methodology that identifies the onset of flood and pre-flood conditions in distillation and separation columns.

Impact

- Allows refiners to operate columns closer to their true hydraulic limit
- Predicts and avoids flood conditions to improve productivity
- Avoids lost production, energy, and other costs associat with flooded columns



Technology Readiness



Estimated Time to Market

1-2 years

Technology Developer: 2ndpoint, LLC

Distillation Column Flooding Predictor™

- PROBLEM: Distillation columns are sometimes pushed past their limits, resulting in flooding. Flooding can result in off-spec products that must be re-distilled. Equipment damage may also occur.
- DESCRIPTION OF INVENTION/TECHNOLOGY: The advanced process control methodology identifies a column's hydraulic limit, or incipient flood point. It allows the column to operate at optimum conditions just below flooding.
- IMPACT: Requires less energy to operate compared with conventional emissions control technology.
- IP POSITION: One patent. The name Flooding Predictor™ is trademarked.
- TECHNOLOGY STATUS:
  - Oak Ridge National Laboratory is managing further verification and validation in response to interest from industry.
  - The technology is expected to be available for licensing after testing is completed this year.

Technology Developer: 2ndpoint, LLC

Waste-Heat Powered Ammonia-Absorption Refrigeration

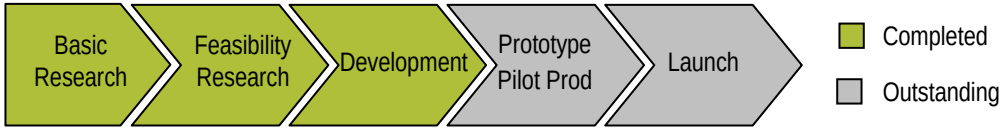
Description

High-performance heat and mass exchangers and a vapor-exchange cycle utilize lower-temperature waste heat to power the ammonia-absorption refrigeration process.

Impact

- Reduces product costs by utilizing lower-temperature waste heat
- Increases refinery throughput
- Decreases carbon emissions

Technology Readiness



Estimated Time to Market

3-5 years

Technology Developer: Energy Concepts Company

Waste-Heat Powered Ammonia-Absorption Refrigeration

- PROBLEM: Refrigeration in the petrochemical and chemical industries consumes tremendous amounts of energy. Ammonia-absorption refrigeration is widely used alternative, but has not taken advantage of waste-heat utilization until now.
- DESCRIPTION OF INVENTION/TECHNOLOGY: Ammonia-absorption technology has been enhanced by adding compact, high-performance heat and mass exchangers, along with a vapor-exchange cycle that uses lower-temperature waste heat.
- IMPACT: The new heat-activated heat pump and chiller supply 1.4 Btu of heat pumping and 0.6 Btu of chilling for every Btu of input fuel.
  - Can use waste heat or solar heat
  - Ability to use lower-temp heat enables the technology to be used in broader applications
- IP POSITION: Energy Concepts Company owns patents on compact, high-performance heat and mass exchangers and will own any new IP emerging from this project, as well. Patent pending on the vapor-exchange cycle.
- TECHNOLOGY STATUS:
  - A half-scale pilot system has been commissioned in Nov. 2007 to demonstrate the technology's viability for producing para-xylene.

Technology Developer: Energy Concepts Company

Agenda

- Industry Landscape
- Program Objectives
- Technology Commercialization Opportunities
- Unexploited Investment Gaps

Unexploited Investment Gaps:

Gap 1: Competitive balance if carbon tax is enacted in the United States

A significant carbon tax, if enacted in the United States but not throughout the entire world, could have profound impacts ***and opportunities*** for the industrial sector

- Steel industry example: a $50/ton carbon tax would impact integrated steel production costs by more than $50/ton steel*. Integrated steel profit margins are often less than $50/ton.
  - What affect will this have on the U.S. steel industry?
  - What technology opportunities may alleviate this consequence?

Policies to encourage R&D and capital investments could help reduce the impact

- Tax credit (or accelerated depreciation) for efficient and greenhouse-gas reducing industrial equipment
- Low-interest loans or loan guarantees
- Technology funding for development and demonstration

* Source: The Basic Steel Industry, U.S. Dept. of Commerce.

Unexploited Investment Gaps:

Gap 2: Fuel and feedstock flexibility based on energy price differentials

The industrial sector has many opportunities to reduce rising energy price impacts due to its:

- Diversity in the fuels it uses
- Diversity in equipment and processes used among various manufacturing industries
- Capability to self-generate significant amounts of its heat and power needs
- Diversity in the size of manufacturing plants
- Geographically dispersion across the United States

Policies to encourage R&D and capital investments could encourage self-generated industrial energy and lower overall industrial energy costs

- Regulatory policy favorable to combined heat and power (CHP)
- Technology funding for development and demonstration