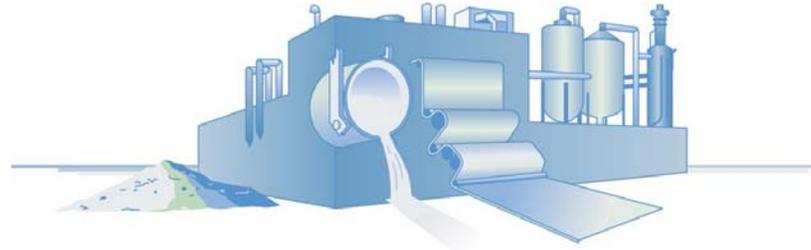




U.S. Department of Energy
Energy Efficiency and Renewable Energy

ITP Technology Portfolio and Accomplishments



Isaac Chan
September 7, 2006

**U.S. Department of Energy
Industrial Technologies Program (ITP)**

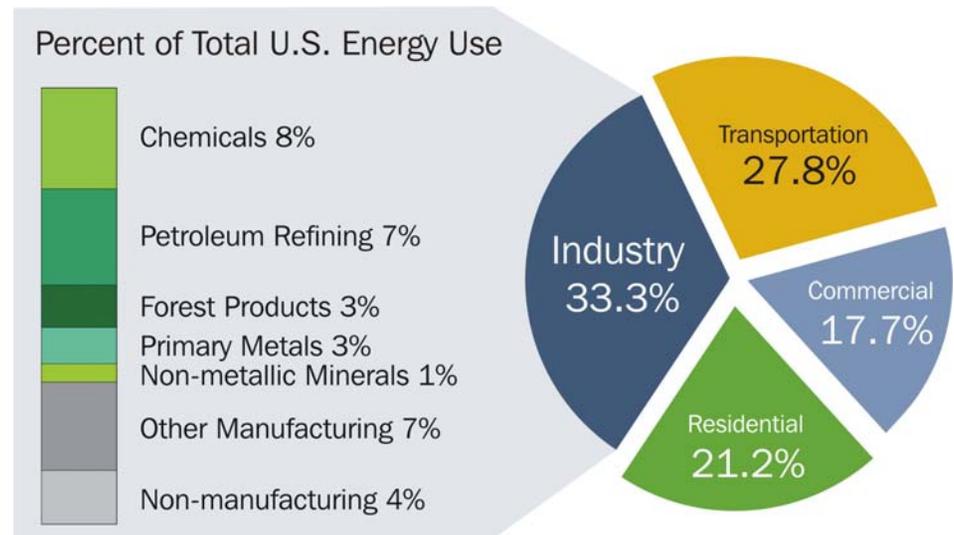


Industrial Technologies Program

ITP is an applied R&D program that fosters the development and adoption of highly efficient technologies, helping our industry to:

- Increase energy efficiency
- Increase fuel flexibility
- Reduce emissions and waste
- Increase productivity

Industry is the largest energy-consuming sector in the U.S.





ITP Program Elements

The keystone of ITP's strategy is our partnership with industry.

We work with industry to:

- Identify R&D priorities
- Conduct technical and market analyses
- Cost-share R&D investments
- Accelerate market adoption of innovative technology solutions
- Provide a variety of resources to help plants save energy

The [DOE Energy Savings Assessment provided a fresh perspective found... energy savings opportunities applied to our system.

– Texas Instruments

With ITP's help, [we] significantly reduced energy intensity over the past 10 years.

– Rohm & Haas

With DOE's help, we found yet more cost-effective opportunities to save energy.

– The Dow Chemical Company

the fuel- These projects and energy benefit the supply chain public at

– U.S. Steel Corporation



ITP's Complementary Roles

Current R&D Portfolio:

Industry-specific R&D

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Steel

Cross-cutting R&D *applicable to all industries*

- Materials
- Combustion
- Sensors & Automation
- Inventions & Innovation

Technology Delivery:

- Save Energy Now
- Industrial energy assessments
- Tool development
- Training
- Technology validation
- Outreach



Aluminum Industry-Specific Portfolio

\$3.2 million in FY06; \$2.3 million in FY07

Objective: Reduce energy intensity of melting secondary aluminum and advanced forming processes

Key Technologies

- **Isothermal Melting Process (ITM)**
Uses direct-immersion heaters to transfer heat to aluminum melting pool via conduction rather than radiation
- **Computational modeling for hot rolling scrap production**
Integrated models that link microstructure to macroscopic properties and rolling process parameters will optimize hot rolling processes, thereby reducing scrap generation



ITP Contact: *Ehr-Ping Huangfu*



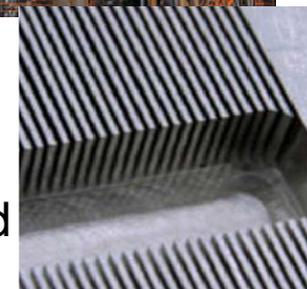
Chemicals Industry-Specific Portfolio

\$7.5 million in FY06; \$6.8 million proposed in FY07

Objective: Improve reaction conversion, selectivity, and separation efficiency in the top 50 energy-intensive chemical processes

Key Technologies

- **Production and separation of fermentation-derived acetic acid**
Allows lower-cost feedstocks and lower temperature and pressure requirements for small-scale acetic acid production
- **Microchannel catalytic reaction technology for on-site H_2O_2 production**
Enable safer on-site production of H_2O_2 by increasing heat and mass transfer rates at lower operating pressures
- **Microchannel for catalytic hydrogenation technology**
Microchannel reactor/heat exchanger system will enable process intensification to reduce steam, electricity, and feedstock use



ITP Contact: Dickson Ozokwelu



Forest Products Industry-Specific Portfolio

\$3.6 million in FY06; \$2.9 million proposed in FY07

Objective: Reduce steam demand in pulp and paper mills by developing advanced water removal technologies

Key Technologies

- **Laser-ultrasonic web stiffness sensor (complete)**
Enables non-contact, real-time measurement of paper stiffness and shear strength on a moving paper web
- **Multiport dryer technology**
Retrofit increases heat transfer and paper drying rates on a cylinder dryer
- **Displacement dewatering press**
Produces a paper web with 65% press solids, thereby reducing energy required to dry the paper



ITP Contact: *Drew Ronneberg*



Glass Industry-Specific Technologies

\$1.7 million in FY06; \$0 proposed in FY07

Objective: Reduce glass melting energy consumption by 50%

Key Technologies

- **High-intensity plasma glass melter (*complete*)**

Dual-torch plasma arc system rapidly melts high volumes of glass in a small-volume melter

- **Next-generation melter**

Oxy-gas-fired submerged combustion melting combined with rapid conditioning produces homogenous glass without stones

- **Advanced oxy-fuel front-end system**

New firing system significantly reduces natural gas consumption and emissions of NO_x and CO₂ in the front-end of a glassmaking furnace





Metal Casting Industry-Specific Portfolio

\$2.5 million in FY06; \$0.9 million proposed in FY07

Objective: Develop advanced melting technologies to reduce energy use, and validate innovative casting technologies to minimize defects and improve yield



Key Technologies

- **“Hot tear” simulation during solidification**
Reduces generation of scrap by predicting dimensional changes and cracking (“hot tears”) during solidification of steel castings
- **“Smart” coating for aluminum pressure die casting dies**
Optimized coating systems enable strain monitoring, indicating initiation of cracks and enabling die life to be extended over 10%

ITP Contact: *Ehr-Ping Huangfu*



Mining Industry-Specific Portfolio

\$1 million in FY06; \$0 proposed in FY07

Objective: Develop advanced technologies to improve mining exploration, extraction, and beneficiation

Key Technologies

- **Crosswell Imaging Technology and advanced drillstring radar navigation for horizontal directional drilling**

Imaging ahead of mining in horizontal holes identifies thinner, more complex deposits and reduces unnecessary drilling and waste generation

- **Conveyor belt inspection for improving mining productivity**
Provides mine personnel with belt quality information before breakage can occur
- **Novel dry coal processing technology**
Mobile deshaling process for use near mine extraction point reduces material haulage to preparation plants and disposal areas





Steel Industry-Specific Portfolio

\$3.6 million in FY06; \$3.6 million proposed in FY07

Objective: Reduce energy intensity in steel manufacturing and develop next-generation production concepts

Key Technologies

- **Cokeless ironmaking (complete)**

Single process produces high-quality iron nuggets from low-grade iron ores and pulverized coal

- **Aluminum-bronze exhaust hood for EAF and BOF**

Corrosion-resistant materials double the life of steelmaking furnace hoods, roofs, and sidewalls

- **Next-generation process to continuously melt, refine, and cast quality steel**

Produces high-quality steel in one continuous process from scrap melting to casting





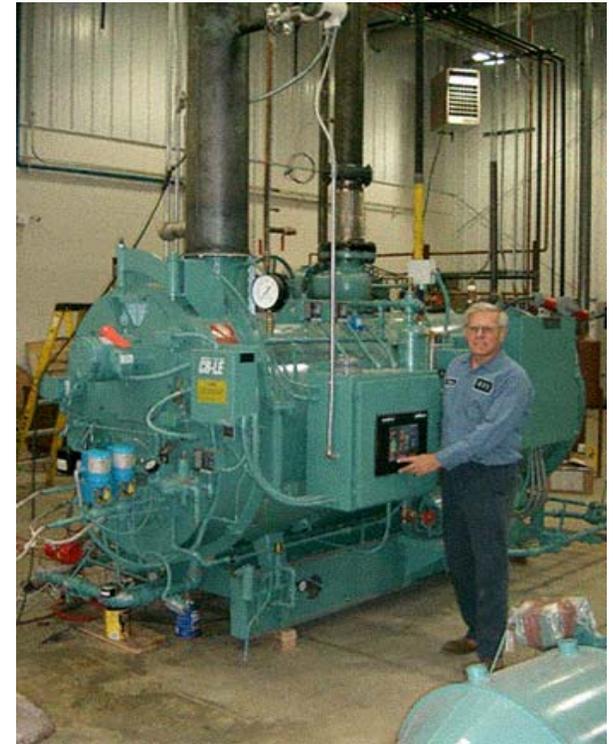
Combustion Portfolio

\$0 million in FY06; \$2.4 million proposed in FY07

Objective: Increase industrial combustion system efficiency while promoting industrial productivity and minimizing environmental impacts

Key Technologies

- **Ultra-high efficiency, ultra-low emissions boilers (>94% efficiency, <2 ppmv NO_x)**
Two main configurations: SuperBoiler for firetube configuration and SuperBoiler second-generation technology for watertube boilers
 - Modular, high-efficiency, low-emissions package boiler
 - Multi-staged printed circuit boiler for industrial applications



ITP Contact: Bob Gemmer



Materials Portfolio

\$11 million in FY06; \$9.8 million proposed in FY07

Objective: Develop degradation-resistant materials and economical protective systems to increase process efficiency and decrease downtime

Key Technologies

- **Materials resistant to metal dusting**
Resist metal dusting attack at temperatures up to 800°C for more efficient high-temperature chemical processes
- **Ultra-nanocrystalline diamond coatings for pump seals**
Reduce pump shaft frictional torque and frictional energy losses by 75%
- **Ultra-hard boride coatings**
Improve resistance to friction and wear, increasing component life for hydraulic components and cutting tools



Commercial alloy (left) and newly developed alloy (right) after exposure to same corrosive environment (5,700 hrs at 593°C)

ITP Contact: Sara Dillich



Sensors & Automation Portfolio

\$3.1 million in FY06; \$3.1 million proposed in FY07

Objective: Enable energy efficiency through operator-independent process control with real-time, on-line integrated measurement systems

Key Technologies

- **Industrial wireless sensors for infrastructure monitoring and process control** (three projects)

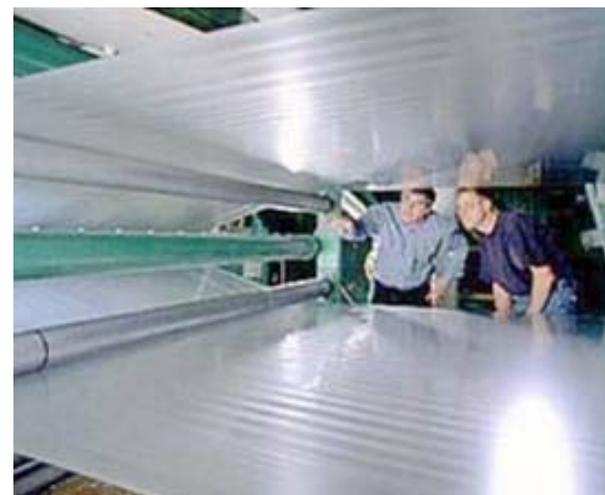
Robust communications reduce maintenance and improve productivity

- **Machine vision detection of surface flaws in metals processing**

Delivers on-line, automatic root-cause identification of surface defects

- **High-speed microanalyzer for gaseous process streams**

Compact sampling system analyzes composition of gaseous and liquid process streams



ITP Contact: *Gideon Varga*



Inventions & Innovations

\$3 million in FY06; \$0 million proposed in FY07

Objective: Provide grants to individual inventors and small businesses to develop innovative technologies that achieve a commercialization rate over 25%

Key Technologies

- **Manufacturing ceramic products from waste glass**

Substitutes raw materials with recycled glass waste

- **Powering cell phones with fuel cells running on renewable fuels**

Micro fuel cell recharges battery and fits inside mobile devices

- **Ice Bear™- thermal energy storage for small packaged terminal air conditioning unit**

Built-in unit produces ice at night to cool AC refrigerant during the day

- **Hot billet surface qualifier (based on HotEye™)**

Provides accurate and timely information about steel surface quality



ITP Contact: Lisa Barnett



Accomplishments

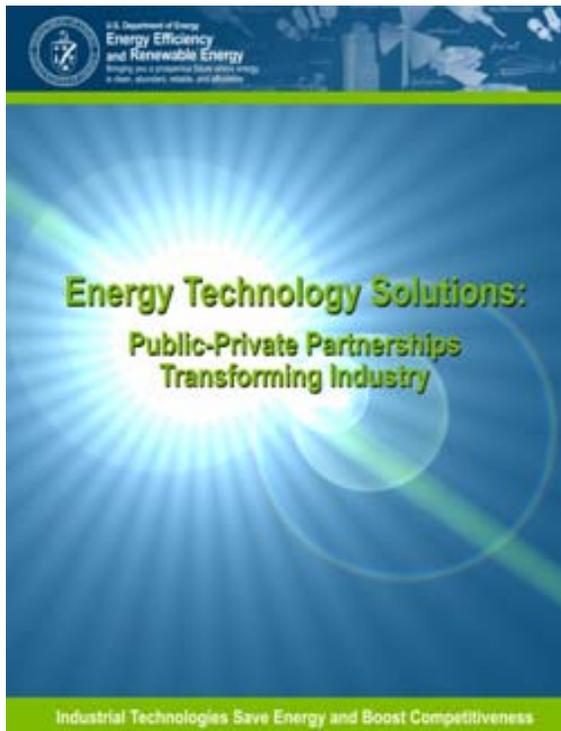
ITP's proven track record:

- Over 170 technologies have entered commercial markets through ITP cost-shared R&D projects with industry
- Nearly 5 quads of energy (worth ~\$23 billion) have been saved since program inception; 366 trillion Btu saved in 2004 alone
- 31 ITP-sponsored technologies won *R&D 100* Awards between 1991 and 2005; 8 more winners in 2006
- 156 patents issued for ITP-sponsored R&D between 1994 and 2005
- Over 13,000 U.S. manufacturing plants have improved their efficiency through ITP's Technology Delivery outreach activities





ITP Successes: Energy Technology Solutions



“ITP Product Catalog” highlights commercial and emerging technologies from recent years

- Public-private partnerships accelerate technology development
- All commercialization accomplished by private industry
- Most commercialization partners are small, entrepreneurial companies

Energy Technology Solutions is available at

<http://www.eere.energy.gov/industry>



R&D 100 Awards

- “Oscars of Invention”
- *R&D Magazine* bestows awards each year to the 100 most promising technologies, products, and processes
- Notable past winners:
 - Anti-lock brakes
 - Automated teller machine
 - Taxol anticancer drug
 - HDTV



ITP cost-shared projects won 8 R&D 100 Awards in 2006



2006 R&D 100 Awards

Isothermal Melting (ITM) Process



Revolutionary melting process cuts energy use by more than half and emissions by >80%.

- Direct-immersion heaters transfer heat to the melting pool via conduction
- Converts 98% of electrical energy to heat
- Zero in-plant emissions
- Commercially available from Apogee Technology, Inc.

TMA[®] 6301 and TMA[®] 4701

Durable, heat-resistant, cast austenitic steels provide higher strength at higher temperatures.

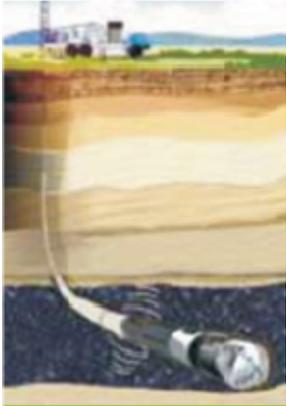


- Computer-aided design methodology reduces time required for developing new alloys by over 50%
- Estimated annual savings of 15 trillion Btu and over \$60 million
- Extends maximum operating temperature by 50°C



2006 R&D 100 Awards

Data Transmission System™



Communication system using two-way radio frequency enables mining operators to compile data 300 times faster than before.

- Uses entire drillstring and immediate surrounding rock layers as the data transmission channel
- Supports measurement-while-drilling applications to identify deeper, thinner, more complex ore deposits
- Increases operating efficiency and accuracy

Metal Infusion Surface Treatment

On-site treatment infuses up to 51 elements into surfaces of metal and alloy equipment to increase service life.

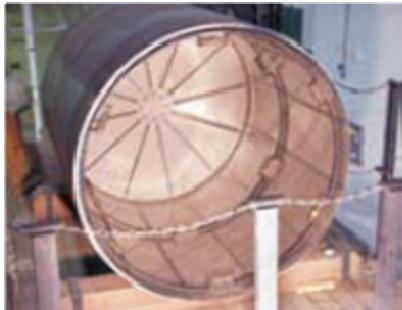


- Nanostructured coating secures the elements to the substrate and prevents flaking and spalling
- Improves service life of aluminum die casting components by 30-50X
- No expensive equipment needed



2006 R&D 100 Awards

Multiport Dryer



Affordable retrofit to paper drying cylinders significantly increases heat transfer to the paper web.

- Increases productivity by up to 50%
- 17 trillion Btu in industry-wide annual energy savings by 2030
- Retrofits to existing dryers at one-fifth the cost of a new dryer

HotEye™ Steel Bar Inspection System

Fully automatic, in-line machine vision inspection finds defect type, severity, and location in real time.



- Inspects the surfaces of hot-rolled pieces moving at 200+ mph
- 2 trillion Btu in energy savings expected by 2010; 33 trillion Btu by 2020
- Reduces surface-related product rejections by 50%



2006 R&D 100 Awards

Alloys Resistant to Metal Dusting Degradation



Corrosion-resistant alloys withstand hydrocarbon-containing atmospheres at temperatures up to 816°C.

- More efficient reformer heat recovery; avoids energy-intensive gas quenching
- 13 million std m³/day in estimated gas savings
- Long-range potential for hydrogen production, methanol reforming, and syngas systems

Laser-Ultrasonic Web Stiffness Sensor

Non-contact, real-time measurement system monitors paper stiffness and shear strength on a moving paper web.



- Eliminates manual sorting
- Estimated \$1.73 million in energy cost savings for a 175,000 metric ton/year uncoated freesheet machine
- Reduces need for recycling out-of-spec paper



Significant Technologies in 2006

Isothermal Melting (ITM) Process



- Continuous flow system uses immersion heaters that convert electricity to melting energy with 98% efficiency
- Reduces energy input and floor space by more than 50% compared to conventional furnaces
- Zero in-plant emissions
- April 2006 ribbon-cutting ceremony highlighted scale-up demonstration at a General Motors facility

SuperBoiler

- Gas-fired package boiler incorporating innovative concepts in burner, heat transfer, heat recovery, and control components
- Capable of achieving thermal efficiencies $\geq 94\%$
- Firetube boiler in demonstration phase; efforts underway to develop high-pressure watertube boiler





Equipment

2006 Accomplishments

- Demonstrated first-generation SuperBoiler at 94% thermal efficiency
- Demonstrated HotEye™ for reducing steel surface defect rejection rates by 50%
- Submerged combustion melter for glass to reduce energy use by 23%, capital costs by 55% (pilot-scale testing complete)
- Demonstrated front-end system extending the glassmaking oxygen-enriched fuel technology with 50% energy reduction (plant-scale)
- Completed aluminum-bronze BOF hood endurance test to minimize downtime
- Demonstrated lignin sensor for detecting different paper grades
- Completed development of advanced process heater to deliver uniform heat profile at 95% thermal efficiency, NO_x emissions <10ppm
- Demonstrated vulcanized splice integrity detection system to reduce unexpected mining conveyor belt failures by 70%





Process Improvements



2006 Accomplishments

- Validated weld overlay that resists corrosion, wear, and dross-buildup, extending service life by a factor of 5
- Developed GAST, a multi-layered, thin film, thermoelectric material for enabling efficient waste heat recovery
- Demonstrated a new surface-hardening technology, LTCSS, that improves stainless steel hardness 100%
- Lab-scale demonstration of biolytic process using synthetic gas to produce acetic acid
- Lab-scale demonstration of multi-channel, microreactor technology for in-situ production of pharmaceutical chemicals in adequate concentrations
- In-plant demonstration of a low-cost process modification to reduce VOC emissions from wood processing by over 60%



Scientific Knowledge

2006 Accomplishments

- Developed CorrosionAnalyzer software package to predict the corrosion of fabricated chemical processing equipment components
- Demonstrated accuracy of Galvanizing Energy Profiler and Decision Support System
- Completed concept definition for a continuous melting, refining, and casting technology for steel production
- Developed a wireless sensor protocol to reduce industrial motor use by 5-10%
- Lab-scale validation of 2% energy savings with a miniaturized instrument to improve ethylene production process control





Factors for ITP's Successes

- Solid working partnerships with industry
- In-depth understanding of industry priorities
- Use of industry experts and merit review system to select promising projects
- Effective program management
- Dedicated staff





Moving Forward

- **Investigate cross-cutting R&D** to save energy in the top energy-consuming processes across industry
- **Expand fuel and feedstock flexibility** to give manufacturers options for responding to energy prices and supply pressures
- **Invest in next-generation**, adaptable technologies to revolutionize manufacturing processes
- **Apply our planning and analysis** to identify the greatest energy-savings opportunities and develop robust market transformation strategy
- **Institute rigorous stage-gate** project and portfolio management procedures
- **Emphasize commercialization planning** throughout the R&D life cycle
- **Encourage private investments** in energy efficiency through new partnerships and strategies with industry

