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

industrial technologies program

DOE-EERE ITP
Materials Portfolio Review

Chicago, IL
June 1, 2005

Sara Dillich
Industrial Technologies Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy

Industrial Technologies

David Rodgers, Program Manager

Technology Delivery

Advanced Process Systems

- Materials, Sensors & Automation
- Metals & Mining

Chemical and Enabling Technologies

- Industrial Energy Systems
- Chemical & Allied Processes

Industrial Technologies Program

- David Rodgers, Acting Program Manager

Technology Manager:

Sara Dillich Materials

Golden Field Office:

Mahesh Jha Materials

Materials sub-program Support

- Pete Angelini (ORNL)
- Ross Brindle (Energetics)
- Gareth Williams (Energetics)
- Bill Choate (BCS)
- Rennie Friedman (BCS)

- Glenn Whichard (Sayres) - full time Materials support
- Scott Birkmere: Golden Office Materials Support

ITP Program Areas

Industry Specific

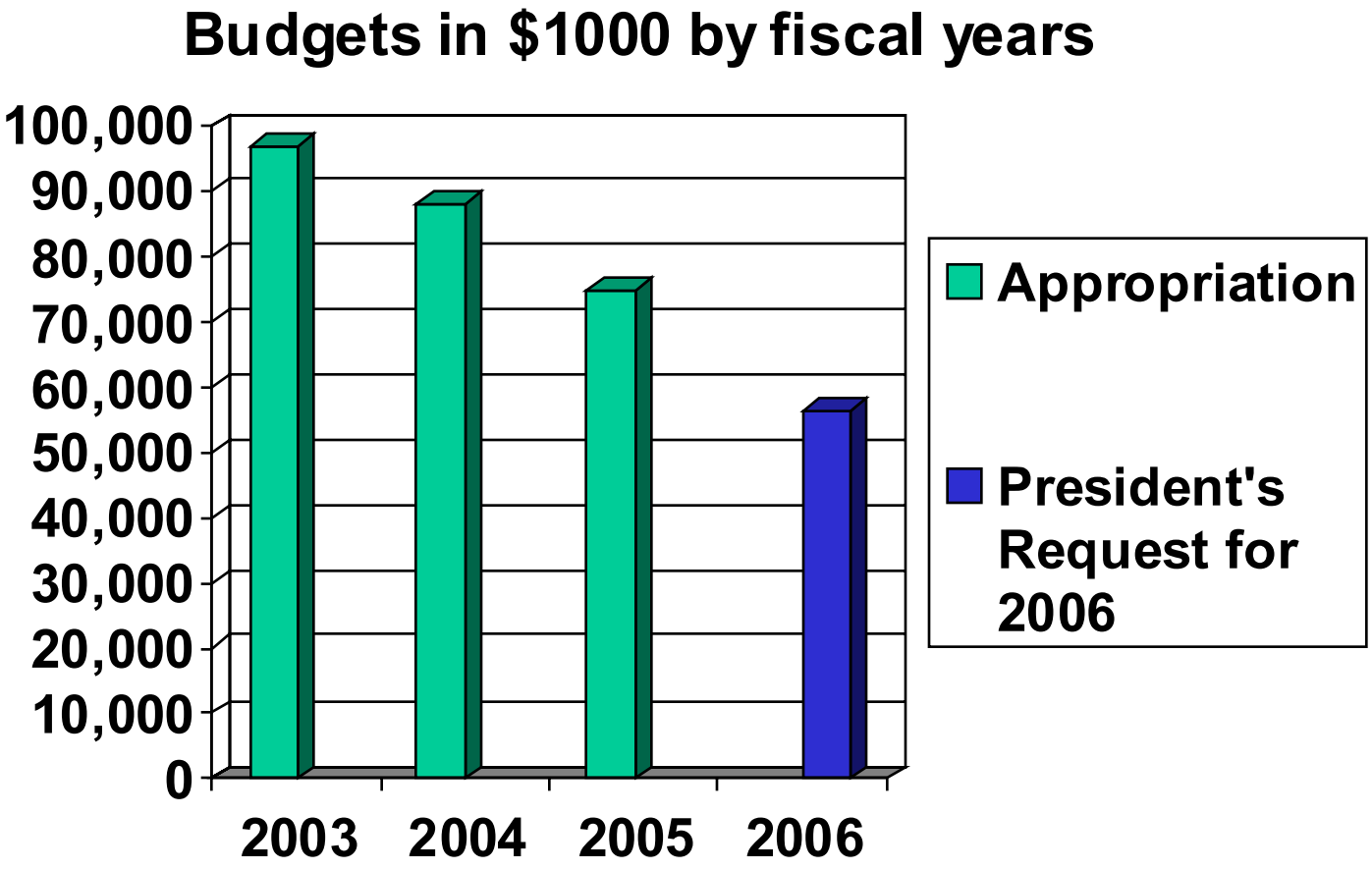
- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum
- Steel

Crosscutting Technologies

- Combustion
- Sensors & Automation
- Materials
- Supporting Industries

Best Practices

ITP's Total Budget



ITP Materials Sub-program

MISSION

Mission - Lead a national effort to research, design, develop, engineer, and test new and improved materials for energy efficiency in industrial processing and manufacturing.

FY04	FY0	FY05(request)
$12.7M	$10.8M	$11.M

Materials FY 2005 Portfolio

24 funded projects in FY2005

Projects by Focus Area

Degradation Resistant Materials (14)

Materials for Energy Systems (6)

Materials for Separations (1)

Thermophysical Databases and Modeling (3)

Portfolio Focus Areas

- **Degradation Resistant Materials**
  - Advanced Processing and Coatings
  - Ultra-Hard Materials
  - Metal Dusting Prevention
- **Materials for Energy Systems**
  - Refractories
  - Materials for Energy Recovery
- **Materials for Separations**
  - Membranes, Zeolites, Filters
- **Thermophysical Databases & Modeling**
  - Degradation Prediction, Transformations & Kinetics Modeling and Simulations

R&D Investment Strategy

Investment Strategy based on

- **Analysis** of energy savings opportunities

- Portfolio balance: want **transformational technologies** as well as incremental improvements

- Emphasis on **high risk, high potential impact** R&D will continue to grow

Recent Materials Analyses

Recent Reports :

- Materials for Separations
- Refractories
- Energy Use, Loss and Opportunities Analysis

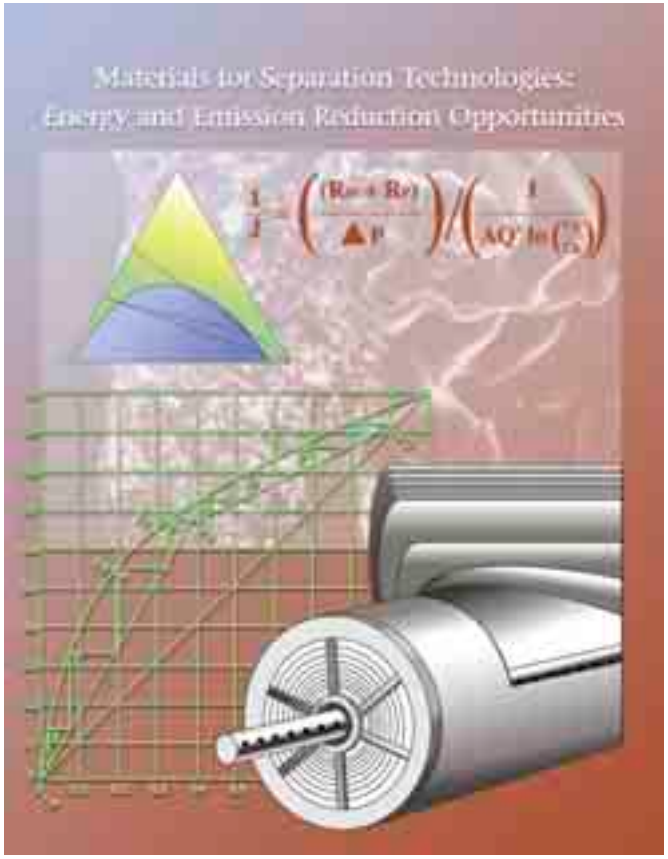
In preparation:

- Corrosion: Energy Savings Opportunities
- Materials for Waste Heat Recovery

Analysis Report - Materials for Separation Technologies

Separation technology crosscuts manufacturing industries

- accounts for ~4,500 TBtu/yr, or about 22% of all in-plant energy use in the US;
- four largest energy consuming industries include (chemicals, petroleum refining, forest products and mining); and
- more than 240 TBtu/yr could be saved by developing new or advanced materials for low energy separations.



www.eere.energy.gov/industry/imf/pdfs/separations_report.pdf

Opportunity Analysis: Refractories for Industrial Processing

Refractories affect large amounts of energy used by U.S. industrial processes

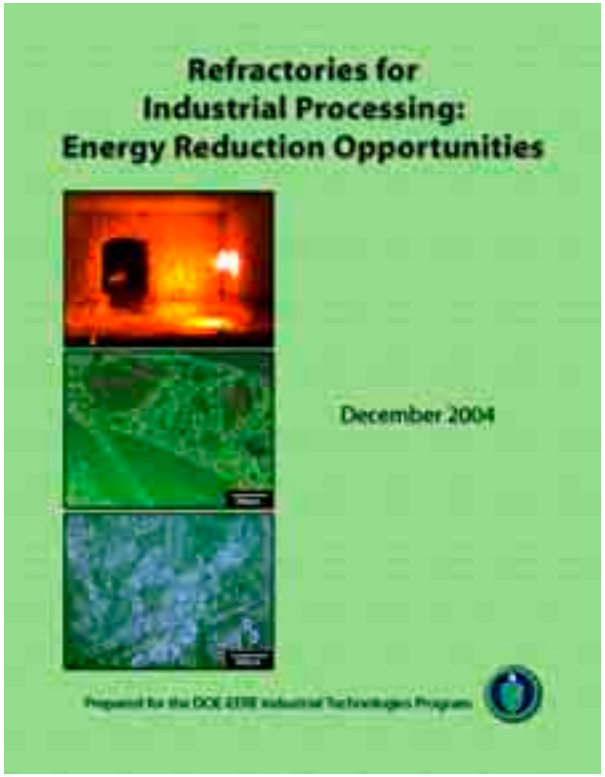
Up to 400 TBtu/yr potential energy savings from refractory improvements in just 4 furnace types:

Boilers and reaction systems

Reverbatory furnaces

Gasifiers

Kilns/Calciners



- Energy savings goals based on the needs and estimates of 15 furnace types used throughout the various manufacturing industries.
  www.eere.energy.gov/industry/imf/pdfs/refractoriesreportfinal.pdf

Energy Use, Loss and Opportunities Analysis : *U.S. Manufacturing & Mining*

The industrial sector uses about one-third of the total energy consumed annually in the United States, costing approximately $100 billion

- 16 energy-intensive industrial sectors were chosen for opportunity analysis
- a series of *energy footprints* was developed to map the flow of energy supply and demand
- using the footprints, the 16 sectors were compared and ranked
- the top 20 R&D opportunities were identified

www.eere.energy.gov/industry/energy_systems/pdfs/energy_use_loss_opportunities_analysis.pdf

- Transformational Technologies
- Stage Gate Process: Risk Management and Project Planning
- GPRA Analysis of Benefits

Transformational Technologies

Ultra-Hard Materials →

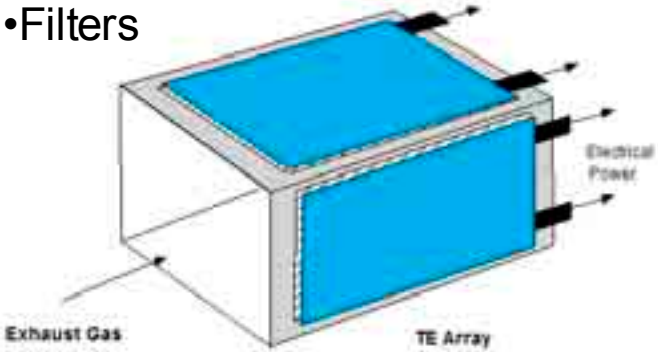
- **Ultrananocrystalline diamond**
- **Diamond composites**
- **Boron-aluminum-magnesium**
- **Nanocrystalline tungsten carbide**

← **Materials for Separations**

- Design Systems
- Membranes
- Sorbants
- Filters

Materials for Energy Systems →

- Waste heat recovery - thermoelectrics
- Emissions conversion – molecular sieves
- Improved efficiency - refractories



Materials for Energy Loss Recovery

Waste to Electricity

Current Technologies

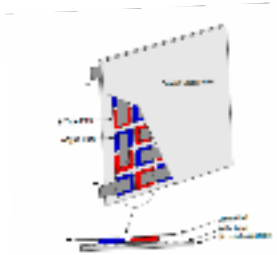
e.g. Heat Exchangers / Recuperator

Materials and design pathways for efficiency gains

- Improved structural materials*
- Improved refractories*)
- High efficiency heat transfer - Microchannel heat exchangers

Future Technologies

Thin film thermoelectrics for waste heat recovery*) Potential savings 18 TBtu/yr by 2020



Schematic of thin film material configuration

Other possible pathways

- Piezoelectric
- Thermophotovoltaic

*ongoing R&D

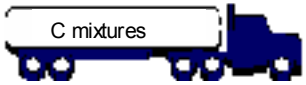
2005
Separations Facility
distillation dominates

2010-2012
Hybrid Systems –
low-energy separation technologies (e.g., membranes) augment distillation

2020
Separations dominated by low-energy intensity systems (new plant footprint)

Examples:

Mixed Hydrocarbon feedstock streams for separations



Ethylene 160 TBtu/yr

Propylene 53 TBtu/yr

p_Xylene* 10 TBtu/yr

Butadiene 4 TBtu/yr

Isoprene* 1 TBtu/yr

Use of Hybrid systems will result in 10-20% Energy Intensity Reduction

Increases in Material

selectivity

throughput

robustness

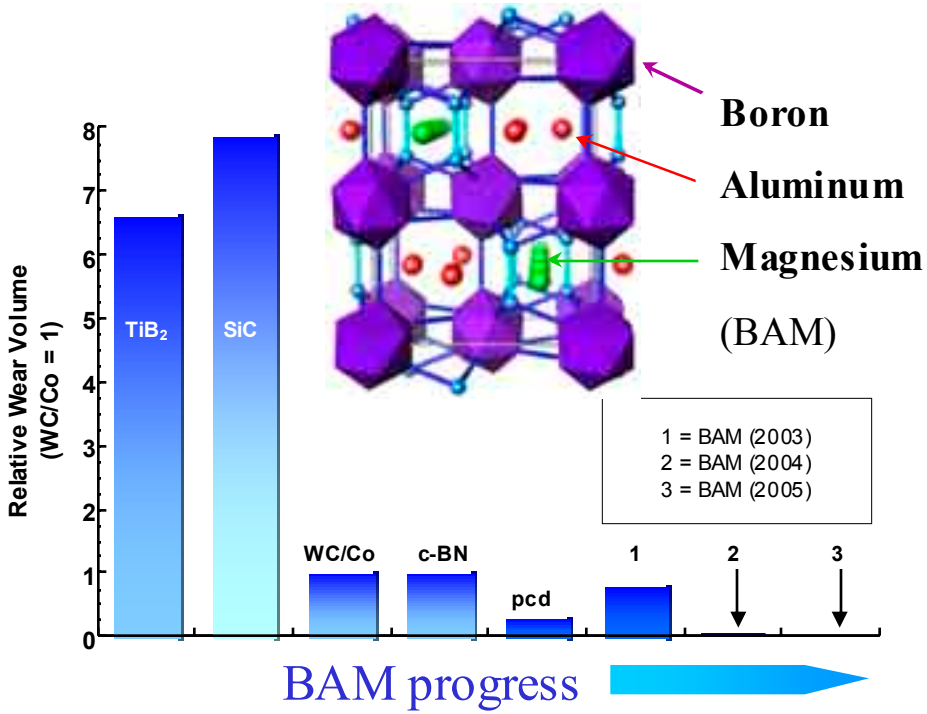
Processes domination by low-energy system could result in 30-60% Energy Intensity Reduction

* Ongoing ITP investigations of separations using modified zeolite membranes

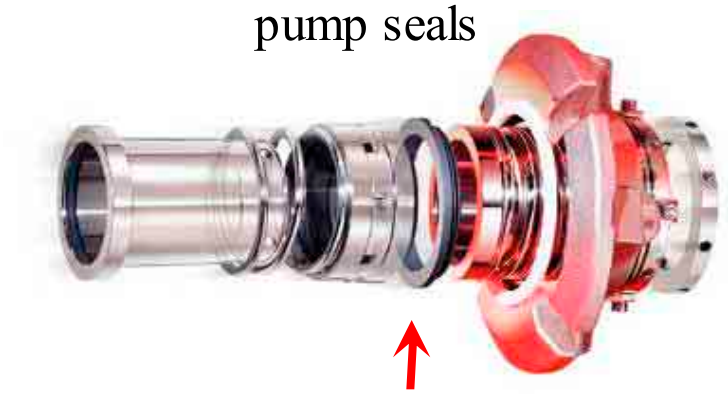
Ultra-Hard Materials

low wear, low friction materials to reduce processing energy

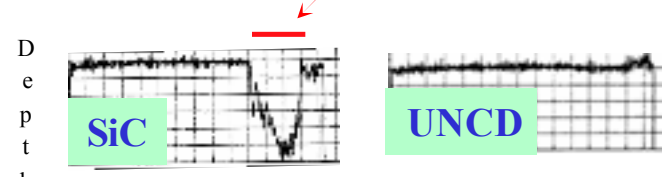
BAM - changing the paradigm from simple structures to multiphase, multicomponent materials for cutting, wear and friction surfaces



Ultra Nano-Crystaline Diamond (UNCD) coatings for mechanical pump seals



significant reductions in friction and wear



Simulation of 2yr in-service wear

Ultra-Hard Materials: Ultrananocrystalline Diamond (UNCD) Coating for Low-friction, Low-wear Rotating Mechanical Seals

Project Milestones and Stage-Gates

Preliminary Investigation
2000-2001

- Installed and optimized a 6" plasma system for film deposition *(2000)*
- Demonstrated growth of UNCD on a variety of substrate materials *(2001)*
- Demonstrated production proof-of-concept on 6" plasma system *(2001)*

Detailed Investigation
2002-2003

- Developed seeding protocols to produce uniform films *(2003)*
- Demonstrated simultaneous growth on multiple 1" seals *(2003)*
- Advanced Diamond Technologies launched, exclusive license *(2003)*

Development
2004-2005

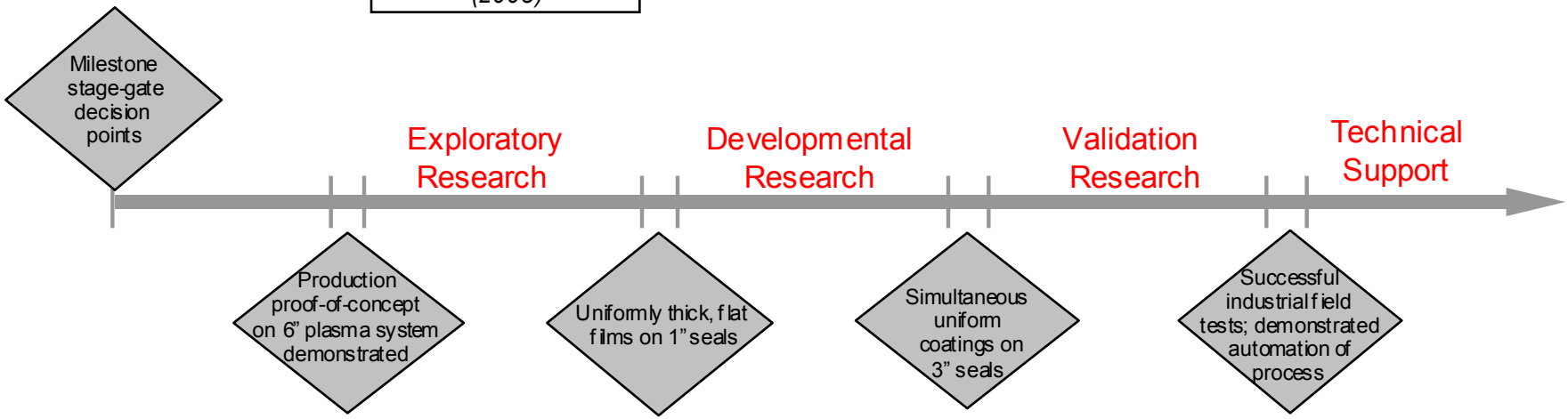
- Commission and optimize an 11" plasma system *(2005)*
- Coated multiple 3" seals simultaneously *(2005)*
- Verify tribological benefits of UNCD coated seals

Validation
2006-2007

- Complete long-term pump tests
- Industrial field tests with 2" and 5" seals
- Evaluate coatings on gas seals

Commercial Launch
2007

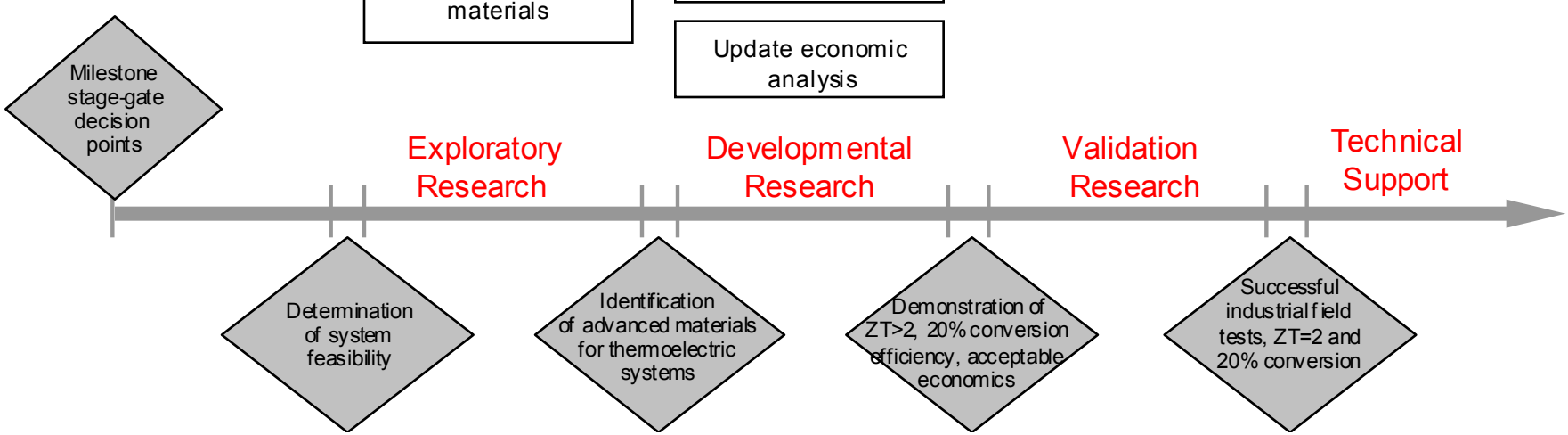
- Toll-processing agreements signed by Advanced Diamond Technologies



Materials for Energy Systems: Advanced Thermoelectric Materials for Efficient Waste Heat Recovery in Process Industries

Project Milestones and Stage-Gates

Preliminary Investigation 2004-2005	Detailed Investigation 2005-2006	Development 2006-2007	Validation 2007	Commercial Launch 2008
System requirements identified and thermoelectric generator designed	Lab tests in simulated industrial environment	Fabricate prototype thermoelectric generator	Demonstrate and test prototype generator in industrial waste heat stack	Technology transfer
Preliminary economic analysis	Initial thermoelectric generator in-plant test	Scale-up and optimize thin film deposition process		Thin film deposition and system scale-up support
	Fabricate and characterize advanced thin film thermoelectric materials	Design industrial prototype thermoelectric generator		
		Update economic analysis		



Government Performance and Results Act

Inputs needed for GPRA Analysis

1. Technology Description
2. Unit Inputs
   - Define typical industrial unit (Furnace, plant, motor, etc.)
   - Energy savings for the unit using new vs. old technology. Savings estimates basis presented in "background" section
   - Other benefits (environmental, financial) not related to energy
3. Market Inputs
   - Number of industrial units in US
   - Growth rate
   - Market share – Units accessible, % Capture
   - Prototype schedule – initial, refined, commercial
   - Dates for commercialization with and without DOE funding
   - Technology class – 5, 10, 20, or 40 years to saturation
4. Expenditure Schedule – DOE and other sources

Outputs from GPRA Analysis

Projections of energy, financial, and environmental savings based on:

- Case 1. With DOE support
- Case 2. Without DOE Support
- Case 3. Net Impact (With – Without)

Projects yearly savings up to the year 2030

Projects cumulative savings up to the year 2030

- Changes in FY2005
- Solicitations and other business
- Attendee form
- Meeting Agenda

Summary: Changes in FY2005

- New administration, new EE-1, new boss, etc
- Materials for Energy Systems Focus Area
- Areas of emphasis for transformational technologies: Ultra-hard Mat'ls, Materials for Energy Recovery, Materials for Separations

2005 Materials Solicitations

See ITP Solicitations calendar on web:
www.eere.energy.gov/industry/financial/solicitations.html

Materials Solicitation: end of June for FY 2007 funds

- Lab Call (20% min cost share)
  (~$2M) for new starts in FY07)
- Industry Call (30% min cost share)
  (~$2M for new starts in FY07)

2005 Solicitation Priorities

- Novel Structures/Materials e.g. Ultra-Hard Materials
- Materials for Sensors
- Advanced Refractories
- Materials for Waste Heat Recovery
- Novel Separations Systems for Low Energy Industrial Separations
- Transformations & Kinetics Modeling and Simulations

Future Solicitations

- More focused, fewer topics
- Emphasis on enabling, cross-industry, transformational technologies
- Go-no-Go decision points identified in cooperative agreements

Other Business

- Started FY05 with $4.2M uncosted

(Started FY04 with $9.0M uncosted)

- Annual project progress reports, Weekly project highlights – Thanks! Keep them coming!

- Labs: Send FY05 FWPs electronically - ASAP

Project Information Dissemination

- Completed Projects
  - Final Reports on web
  - Updated factsheets
  - 3 Technical Highlights in FY2005
  - 3 Case Studies in FY2005

New Technical Highlights

- Infrared Heating Technology; Crosscutting Applications, Widespread Benefits (March 2005)
- Ultra-Hard Borides for Industrial Applications (January 2005)
- Ultrasonic Processing Refines Alloy Microstructure (February 2005)

Case Studies

- Development and Demonstration of Advanced Tooling Alloys for Molds and Dies: A Technology Transfer and Commercialization Case Study of RSP Tooling (2005)
- Advanced Materials for the Pulp and Paper Industry (2005)
- Intermetallics for Manufacturing (2005)

Meeting Attendee Questionnaire

Please fill out and hand in before you leave this week.

Agenda

	Tuesday, May 31	Wednesday, June 1	Thursday, June 2	Friday, June 3
7:00				
8:00		Welcome & 2 Presentations 8:00-9:50	2 Speakers & 2 Presentations 8:00-10:20	3 Presentations 8:00-10:10
9:00				
10:00		Break – 9:50-10:10	Break – 10:20-10:40	Break – 10:10-10:30
11:00		1 Speaker, 1 Presentation 10:10-11:30	3 Presentations 10:40-12:40	3 Presentations 10:30-12:30
12:00		Lunch 11:30-1:00 1 Speaker		
1:00		1 Speaker & 2 Presentations 1:00-2:50	Tour of Argonne National Laboratory 1:00-5:00 (Lunch on bus)	Materials Review Board Meeting (Working Lunch)
2:00	Materials Review Board Meeting			
3:00		Break – 2:50-3:10		
4:00		1 Speaker & 2 Presentations 3:10-5:00		
5:00		Reception 1 Speaker & 3 Poster Displays 5:00-6:30		
6:00				
7:00				
8:00				
9:00				

Legend:
- Informal Event
- Session
- Registration & Meals

- End of Presentation