Appendix C – Industrial Technologies

GPRA 2004 Quality Metrics
Methodology and Results

OFFICE OF INDUSTRIAL TECHNOLOGIES

Prepared by
Energetics, Incorporated
7164 Gateway Drive
Columbia, MD 21046

Prepared for
Office of Industrial Technologies
U.S. Department of Energy
Washington, DC

December 20, 2002

Table of Contents

I. Overview

This report describes the results, calculations, and assumptions underlying the GPRA 2004 Quality Metrics results for all Planning Units within the Office of Industrial Technologies.

GPRA 2004 supports planning activities including the FY 2004 Budget Cycle. The Quality Metrics results essentially depict the future impacts on energy, energy costs, and the environment of EERE's FY 2004 programs assuming their logical continuation. The impacts of pre-FY 2004 program funding are therefore not included in GPRA 2004. With this said, however, the known FY 2003 program portfolio is used in GPRA 2004 as a proxy for the as yet unknown content of the actual FY 2004 EERE portfolio. It is assumed that the FY 2004 portfolio will not be so different than the FY 2003 portfolio that its benefits will vary substantially.

In the results of GPRA 2004, total OIT program energy savings for 2010 were 0.956 quads, which for comparison represents 2.4% of baseline industrial energy consumption in 2010. Year 2020 energy savings were 3.934 quads, or 9.1% of 2020 baseline industrial energy consumption. Projected energy savings in 2030 reached 8.547 quads, or 7.5% of extrapolated baseline industrial energy consumption in 2030. The results are summarized in Table 1 below; details are provided in a set of tables included as *Appendix A*.

Comparison with results of the previous GPRA study is complicated by subsequent organizational changes within EERE that have resulted in the removal of the Black Liquor Gasification program and Bio-based Products, NICE[3,] and Inventions & Innovations planning units from the Office of Industrial Technologies. This report compares the GPRA 2004 results with the previous GPRA 2003 results in two ways: (1) directly, ignoring the fact that large program components were removed between the two studies, and (2) more meaningfully, for only those program components that were considered in both GPRA studies. Both comparisons are documented in *Appendix A*.

In direct comparison with the previous GPRA study, the year-2010 savings were 33% smaller than the 1.417 quads projected in GPRA 2003. Year 2020 savings were 9.4% smaller than the 4.341 quads projected in GPRA 2003. Year-2030 savings were 58% smaller than the GPRA 2003 projection of 8.546 quads. Thus the net study result in GPRA 2004 of several programmatic and many individual analytical changes was a substantial decrease in the 2010 impacts of the OIT programs, a small decrease in mid-term 2020 impacts, and a large decline in longer-term 2030 impacts. These changes are primarily the results of:

- major re-organization of EERE resulting in the removal of the Black Liquor Gasification program and Bio-based Products, NICE[3,] and Inventions & Innovations planning units from the Office of Industrial Technologies, in addition to the normal evolving portfolio changes in the remaining planning units; and
- methodological changes: (1) in accord with EERE Performance Planning Guidance for the FY 2004-2008 Budget Cycle GPRA 2004 benefits are defined as only the accelerated benefits that would not have occurred without OIT's involvement, and (2) the market penetration curve used in the OIT Impact Projections Model was refined in a way that reduced early-year technology penetrations for many technologies.

Focusing specifically on only those OIT program components remaining after the EERE reorganization shows a more directly comparable pattern of changes. The program components that have been removed from OIT had in GPRA 2003 contributed 0.453 quad to 2010 energy savings, 1.662 quads to 2020 energy savings, and 3.746 quads to 2030 savings. Subtracting these quantities – in effect considering only those planning units included in both GPRA 2003 and GPRA 2004 -- total OIT year-2010 savings in GPRA 2004 were nearly identical (964 Tbtu in GPRA 2003 cf. 956 Tbtu in GPRA 2004); year-2020 savings were 1,256 Tbtu higher in GPRA 2004; and year-2030 savings were 1,186 Tbtu lower. Thus – as compared to the equivalent GPRA 2003 results – GPRA 2004 benefits were respectively 1% smaller for 2010, 47% higher for 2020, and 25% lower for 2030.

Seventy-nine percent of the net increases from the previous GPRA study in terms of 2020 energy savings were found in two planning elements – Best Practices (949 Tbtu cf.. 438 Tbtu) and Combustion (586 Tbtu cf. 106 Tbtu). The increase in Best Practices in based on a report by D. Jones, et. al., Oak Ridge National Laboratory, "Preliminary Estimation of Energy Management Metrics of the Best Practices Program," May 2002, with additional OIT staff assumptions. The increase in Combustion was due to correction of an order-of-magnitude error in capacity factor for the Super Boiler project. Additional, much smaller increases in year-2020 benefits were seen in Steel (61 Tbtu), Petroleum Refining (53 Tbtu), Mining (38 Tbtu), and Metal Casting (26 Tbtu).

The number of individual Impact Projections Model runs performed in support of OIT's GPRA 2004 study was 199. For comparison, GPRA 2003 was based upon 274 model runs; however, Black Liquor Gasification, Bio-based Products, NICE[3,] and Inventions & Innovations accounted for 47 runs in GPRA 2003. Additionally, a change in the Forest Products planning unit study methodology for GPRA 2004 in effect combined 37 projects into 13 aggregated model runs. Subtracting these differences makes the comparable number of projects accounted for by the GPRA 2004 study as compared to GPRA 2003 approximately equal (199 cf. 203).

In the GPRA 2004 version of the model, additional emphasis was placed upon identifying project milestones leading to commercial introduction, leading many analysts to assume later commercial introduction years than in last year's study. Probably to counter the tendency towards reduced benefits driven by this and other GPRA 2004 methodological changes cited previously, nearly all analysts (Mining is an exception) tended to choose faster market penetration curves to characterize their technologies. Thus, planning unit portfolios characterized by mostly "c" market penetration curves in GPRA 2003 have trended toward mostly "b" curves in GPRA 2004. This pattern, repeated over nearly all planning units, is responsible for a significant part of the increase in year-2020 benefits, and reflects a level of subjectivity inherent in the GPRA methodology. Each project analysis is based upon limited technical, economic, and market characterization data, and a major market driver – the selection from among four possible market penetration curve slopes – is subject to the analyst's judgement.

Table 1. Office of Industrial Technologies - GPRA 2004 QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	192	956	2,340	3,934	4,241	3,615
2. Baseline Industrial Energy Use[1] (TBtu)	37,530	39,420	41,310	43,390	45,600	47,930
3. Primary Energy Savings as Percent of Baseline (%)	0.5	2.4	5.7	9.1	9.3	7.5
4. Energy Cost Savings (B$)	1.04	5.04	11.3	17.9	20.1	18.8
5. Carbon Reduction (MMTCE)	3.38	17.4	41.5	67.9	71.6	59.8

[1]DOE/EIA, *Annual Energy Outlook 2002*, Reference Case Forecast (years 2025 and 2030 extrapolated from 2010-2020 growth trend).

II. QM Methodology and Results

A. *R&D Planning Units*

GPRA Quality Metrics were projected for individual projects within Planning Units and summed to total results for Planning Units and for OIT as a whole. This prospective assessment was carried out with the aid of an experience-based market penetration model designed to estimate the national energy, economic, and environmental impacts of innovative industrial technologies. Model runs for individual R&D projects receiving R&D support were aggregated to obtain energy savings, value of energy saved, and emission reductions associated with each R&D Planning Unit. In aggregating the savings, market targets were examined explicitly to avoid double-counting the same potential savings in the infrequent instances when the same energy efficiency market is clearly addressed by multiple projects. Where possible market overlaps were found, the markets were either assigned to one technology only or divided among the competing technologies under development. This process increases confidence that any systemic double-counting within planning units has been minimized. Nevertheless, some double counting across Planning Units within OIT or with other EERE programs is assumed to remain. The market penetration model used for the analysis is described in *Appendix B*, which includes a blank copy of the model output and the instructions provided for the model's use.

Estimates of the energy savings are based upon information provided to the analysts through the proposal review and contracting process that includes industry participation and review, followed up by program review of these estimates. OIT analysis by sector has focused on assessing where energy is actually consumed and to understand current and best practices for each proposed technology. The participation by industry experts in this process has been critical to helping refine the estimates.

The approximate portion of the fiscal-year 2003 budget represented by the analysis for each Planning Unit was noted but the results were not scaled to 100 percent of the FY 2003 budget. Typically, the projects analyzed represented 75 to 95 percent of the FY 2003 budget for the various Planning Units (see *Appendix A*). Projected benefits for these Planning Units do not include the effects of R&D projects completed prior to the current year. These impacts are significant and are tracked by Pacific Northwest National Laboratory in a series of surveys of equipment providers and users, most recently reported in *Office of Industrial Technologies: Summary of Program Results, 2001.*

The justification for assuming that all of the projects analyzed will succeed is two-fold. First, projects which fail are assumed to be replaced with new projects using different technical approaches to achieve similar goals, so that in the long run, the basic goals will be met by the program, assumed to be continuously funded. Second, the projects analyzed do not comprise 100 percent of the FY 2003 budget, which in itself discounts the aggregated results, equivalent to incorporating some risk of failure into the overall process. In addition, the knowledge benefits of OIT's R&D portfolio are not assessed here; this scientific and technical knowledge can help to underpin additional production technology innovations in the future.

A limited-distribution, four-volume set of notebooks containing all Impact Projections Model runs supporting the GPRA 2004 process is entitled, "GPRA 2004 Quality Metrics: Supporting Spreadsheets." This set of notebooks provides over 1,400 pages of supporting documentation for the R&D project analyses which form the primary basis for the GPRA 2004 results.

1. Aluminum Industry Vision

Table 2. Aluminum Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (Trillion Btu)	0.7	22	101	199	172	144
2. Energy Cost Savings (Billion $)	0.002	0.09	0.46	1.01	0.92	0.80
3. Carbon Reduction (MMTCE)	0.01	0.55	2.65	5.25	4.24	3.21

The GPRA submission for the Aluminum Vision is based on analysis of 23 technologies related to enhancing the energy efficiency, productivity, and environmental performance of aluminum production (both primary and secondary) and fabrication (see table below). The Aluminum Team's FY 2003 budget is approximately $8.1 million. The projects listed below represent approximately 80% of the budget, compared to the 90% figure for the 21 projects analyzed for the GPRA 2002 submission.

Table 3. Summary of Project Runs – Aluminum Industry Vision

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Primary Aluminum Production	Inert Metal Anode	0.94	19.19	2008/b
	Potlining Additives	0.87	3.47	2005/b
	Intelligent Potroom Operation	0.10	0.40	2005/b
	Low-T Wetted Cathode Cell	3.72	55.57	2007/b
	Carbothermic Reduction	1.42	10.01	2007/c
Secondary Aluminum Production	High-Efficiency, Low-Dross Combustion System	0.08	0.98	2006/b
	Reduced Oxidative Melt Loss	1.47	11.22	2005/b
	Energy Eff Isothermal Melting	1.63	13.89	2006/b
	Energy Efficiency in Al Melting	2.02	13.22	2006/b
	Gas Fluxing of Al (Bubble Probe)	1.83	27.53	2008/b
	Processing of Aluminum Wastes	1.65	8.77	2008/b
Forming	Superior Aluminum Extrusions	0.23	2.22	2006/b
	Modeling Optimization DC Casting/Ingot Cracking	2.78	4.79	2005/a
	Spray Rolling	1.36	8.15	2006/c
	Continuous Cast Al Sheet	0.28	3.41	2007/b
	Plastic Deformation Processing	0.05	0.39	2006/b

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
	Coolant Characteristics	0.02	0.19	2006/b
	Rolling Process Design Tool	0.91	8.24	2006/b
	Formability of Cast Alloys	0.28	3.41	2007/b
	Integrated Method for Thermomechanical Processing	0.09	1.02	2007/b
	Reduction of Annealing Times	0.18	2.04	2007/b
	Surface Behavior of Al Alloys	0.05	0.46	2006/b
	Two-phase Model for Hot Deformation of Highly Alloyed Al	0.02	0.26	2007/b
	Total	21.98	198.83	N/A

Total primary (counting electricity generation and transmission losses) energy savings in 2010 are projected to be about 22 trillion Btu, significantly lower than the GPRA submission for FY 2003 (76 trillion Btu). Year-2020 primary energy savings for the FY 2004 portfolio are projected at about 199 trillion Btu, nearly identical to the 2020 figures in the 2003 submission (194 trillion Btu). This represents approximately one-fourth of the industry's total energy consumption (assuming the majority of U.S. smelters are operating).

Six new university-based projects have been analyzed for the FY 2004 analysis: Gas Fluxing of Aluminum (Bubble Probe), Formability of Cast Alloys, Integrated Method for Thermomechanical Processing, Reduction of Annealing Times, Surface Behavior of Aluminum Alloys, Two-Phase Model for Hot Deformation of Highly Alloyed Aluminum. Four projects (Non-Consumable Anode for Electrowinning, Vertical Flotation Melter and Scrap Dryer, Recycling Aluminum Saltcake, and Textures in Strip-Cast Aluminum Alloys) that were part of the GPRA 2003 submission have been completed (or did not receive funding this year) and have not been included in the 2004 submission.

The energy savings totals shown in the aluminum team benefits spreadsheet reflect only the projects actually analyzed, and have not been adjusted or normalized to reflect 100% of the budget. The savings are fairly equivalent to those in GPRA 2003; the four projects dropped from last year's analysis had somewhat lower energy savings than the six new university-based projects added this year. Additionally, the GPRA methodology has changed since last year, resulting in lower energy savings for all of the projects in 2010. Using the new method, the GPRA result is the energy savings provided by the technology if OIT was not involved subtracted from the energy savings created with OIT's involvement.

There are overlapping markets between two of the projects listed above – Carbothermic Reduction and Inert Metal Anode. Each of these technologies has been assigned approximately one-third of the total potential market for primary aluminum production.

2. Chemical Industry Vision

Table 4. Chemicals Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	7.8	67	382	787	657	410
2. Energy Cost Savings (B$)	0.027	0.23	1.35	2.89	2.72	2.11
3. Carbon Reduction (MMTCE)	0.14	1.14	6.30	12.61	10.72	7.44

Projected benefits for the Chemical Industry Vision were based on analysis of 22 active R&D projects that focus on improvements in energy efficiency and environmental performance of chemical manufacturing processes. The table below identifies these projects, grouping them into separate targets including materials technology, chemical synthesis, computational technology, process science and engineering, and biotechnology. It is estimated that the current funding for these projects represents 59% of the $14.5 million FY 2003 Chemical Industry Vision Portfolio budgdet. The Chemical Industry Vision has just closed a solicitation and several new R&D projects are expected to begin after the GPRA study is completed.

Table 5. Summary of Project Runs – Chemical Industry Vision

Impact Target	Project/Spreadsheet Run File Name	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Materials Technology	Alloy Selection System/ASSET (asset.04)	11.12	107.36	2005/b
	Mixed Solvent Corrosion (alloy.corrosion.model.04)			
	Corrosion Monitoring System (corrosion.monitoring.04)	7.16	60.04	2005/b
	Alloys for Ethylene Production (intermetalics.ethylene.crackers.04)	17.01	164.30	2005/b
	Metal Dusting Phenomenon (metal.dusting.04)	0.02	0.10	2005/b
	SUBTOTAL	**35.31**	**331.8**	
Chemical Synthesis	High Throughput Catalyst Screening (highthrucatalyst.04.new)	2.82	58.63	2007/b
	Selective Oxidation of Aromatic Compounds (directoxida.04)	0.32	13.3	2009/c
	Advanced Autothermal Reformer (autothermal.04)	1.23	19.68	2005/b
	Short Contact Time Reactor (shortcontactreactor.04.new)			
	SUBTOTAL	**4.37**	**91.61**	

Computational Technology	Solution Crystallization Modeling Tools (crystallizer.optimization)	1.22	7.30	2005/b
	Multi-phase Computational Fluid Dynamics (CFD) (cfdrollup1)	1.47	12.13	2004/b
	Molecular Simulation for the Chemical Industry	0.50	14.32	2008/b
	Reaction Engineering Workbench	3.05	24.88	2005/b
	Distillation Column Modeling Tools (distillation.column.model)	6.04	84.73	2007/b
	SUBTOTAL	**12.28**	**143.36**	
Process Science and Engineering				
Separations	Membranes for p-Xylene Separation (advmat.04)	1.61	52.91	2007/b
	Mesoporous Membranes for Olefin Separations (mesopormembrane.04.new)	1.24	34.50	2007/b
	Purification Process for PTA (pta.purification)	0.28	4.38	2006/b
	Membranes for Corrosive Reactions (membranes.oxidative.reactions a)(membranes.oxidative.reactions b)	0.56	13.16	2007/b
	SUBTOTAL	**3.69**	**104.95**	
Process Engineering	Enhanced Heat Exchangers for Process Heaters (dimpletube.process.heaters)	1.29	11.08	2005/b
	Ethylene Process Design Optimization (ethylene.process.04.new)	2.6	32.84	2006/b
	SUBTOTAL	**3.89**	**43.92**	
Chemical Measurement	Accelerated Characterization of Polymer Properties (microanalysis.polymer.properties)	0.93	10.23	2008/a
Bioprocesses and Biotechnology	Development of Non-Aqueous Enzymes	5.97	60.78	2006/b
	SUBTOTAL	**6.9**	**71.0**	
	Total	66.84	786.77	

Rev. 06/28/02

Energy consumption in the chemicals industry is very complex, involving a great number of processes manufacturing thousands of products. Hydrocarbon fuels used as chemical feedstocks, according to the 1998 MECS, accounted for about 2.7 quads of energy use, about 46% of the industry's 6 quads of primary energy use. Separations and process heating are responsible for much of the remaining energy use. It is reported that distillation, one of the most widely used separation processes in the chemical industry, accounts for as much as 40% of the industry's total energy use for heat and power. The Chemical Industry Vision focuses much of its efforts on these energy intensive processes, and on improving the efficiency and yield of chemical processes.

Total primary energy savings in 2010 for the Chemical Industry Vision are projected to be about 67 trillion Btu, approximately one-third the GPRA submission for FY 2003 (233 trillion Btu). Year 2020 energy savings for the FY 2004 portfolio are projected at about 786 trillion Btu, which is at the same level as the GRPA submission for FY 2003. For comparison, year 2010 projected energy savings are about 1% of 2000 energy use in the chemicals industry (6,064 trillion Btu).

Changes from the GPRA 2003 submission are due to the deletion of 13 projects and changes in the market penetration model. The large decrease in 2010 is due primarily to changes in the model.

3. Forest Products Industry Vision

Table 6. Forest Products Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	0.12	14	97	267	344	371
2. Energy Cost Savings (B$)	0.0004	0.04	0.24	0.70	0.94	1.06
3. Carbon Reduction (MMTCE)	0	0.15	1.01	2.74	3.53	3.80

Projected benefits for the Forest Products Industry Vision were estimated using an analytical process very different from that used in years past. In past years, the GPRA summary submission was based on a roll-up of the results from spreadsheet analyses of the individual projects funded in the current fiscal year. For example, the FY03 GPRA submission was a rollup of 56 of 60 active R&D projects funded by the program in FY02. For the FY04 GPRA process, the analysis was focused on 13 different *energy focus areas* into which 37 active R&D projects were grouped. That is, spreadsheet analyses were done to estimate benefits of the specific focus areas (e.g., Recovery Boiler Efficiency or Paper Drying) rather than of the individual projects that address each area. In this way, overlap between projects that address similar markets is avoided and a more accurate assessment of the ultimate potential is achieved. Table Y shows the summary of GPRA 2004 benefits achievable in each of these focus areas, and a list of the projects that fall into each area. It is estimated that the 37 projects represent over 74% (more than $7.4 million) of the $10.03 million FY 2003 budget for the Forest Products Industry Vision (remainder is for new awards and non-R&D activities).

The FY04 energy savings estimates are significantly less than those projected in FY03 because black liquor gasification is not included in this year's GPRA analysis for Forest Products (the gasification projects have been moved to EERE's Office of the Biomass Program). Without gasification, the estimates are very close for the year 2020: the FY03 estimated energy savings was 257 trillion Btu and in FY04 the estimate is 266. For the year 2010, the numbers are significantly lower in FY04 (14 trillion Btu compared to almost 80 trillion Btu in FY03) due to later estimates for market introduction.

The current portfolio includes projects that were selected by competitive solicitations issued cooperatively by DOE and the American Forest & Paper Association (AF&PA). Target areas for the solicitations were developed by expert task groups and were based on the forest products industry's vision and technology roadmaps.

Table 7. Summary of Project Runs – Forest Products Industry Vision

Impact Target and Projects	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Improved Pulping Yield & Decreased Pulping Energy • Molecular Physiology of Nitrogen Allocation • Dominant Negative Mutations of Floral Genes • Genetic Augmentation of Syringyl Lignin in Low_lignin Aspen Trees • Quantifying and Predicting Wood Quality of Loblolly and Slash Pine Under Intensive Forest Management • Exploiting Genetic Variation of Fiber Components and Morphology in Juvenile Pine • Environmental Influences on Wood Chemistry and Density of Populus and Loblolly Pine • Accelerated Stem Growth Rates and Improved Fiber Properties of Loblolly Pine • Increasing Yield of Kraft Cooks Using Microwaves • Novel Pulping Technology: Directed Green Liquor Utilization (D_Glu) Pulping	1.8	35.6	2007/b
Recovery Boiler Efficiency • Materials for Kraft Recovery Boiler • Intermediate_sized, Entrained Particles • CFD Modeling, Shape Optimization and Feasibility Testing of Advanced Black Liquor Nozzle Designs • Improved Recovery Boiler Performance Through Control of Combustion, Sulfur and Alkali Chemistry • Development of Corrosion Resistant Chromium Rich Alloys for Gasifier and Kraft Recovery Boiler Applications	3.4	60.8	2007/b
Paper Drying • Multiport Cylinder Dryers • Uniform Web Drying Using Microwaves • Laboratory Development of a High Capacity Gas_Fired Paper Dryer • Development of a Continuous Process for Displacement Dewatering	2.2	46.8	2007/b
Decreased Paper Basis Weight for Paperboard • On_Line Fluidics Controlled Headbox • The Lateral Corrugator • Acoustic Foils for Enhanced Dewatering and Formation • Contactless Monitoring of Paper • Non_Contact Laser Acoustic Sensor	2.3	45.9	2007/b
Bleaching • High Selectivity Oxygen Delignification • Higher Selectivity Oxygen Delignification	1.0	18.4	2007/b
Causticizing • Use of Borate Autocausticizing to Supplement Lime Kiln and Causticizing Capacities	0.6	12.7	2007/b
VOC/HAP Emission Control • Plasma Technologies for VOCs • Improving Dryer and Press Efficiencies Through Combustion of Hydrocarbon Emissions	1.0	19.9	2007/b

Impact Target and Projects	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Improved Paper Machine Efficiency • Screenable Pressure Sensitive Adhesives • Decontamination of Process Streams Through Electrohydraulic Discharge	0.06	1.07	2007/b
Recycling OCC • Preventing Stength Loss of Kraft Fiber	0.4	7.8	2007/b
Deinking • Surfactant Spray to Improve Flotation Deinking	0.06	0.09	2007/b
Wood Boiler Efficiency • Methane de_NOX	1.0	7.1	2004/b
Lumber Drying • Microwave Treatment for Rapid Wood Drying • Wireless Microwave Wood Moisture Measurement System for Wood Drying Kilns	0.2	4.7	2007/b
Wood Panel Pressing • Fast Curing of Composite Wood Products • Rapid, Low Temperature Electron X_Ray and Gamma Beam Curable Resins	0.3	4.9	2007/b
TOTAL	**14.32**	**265.76**	

4. Glass Industry Vision

Table 8. Glass Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	1.1	8	40	68	47	18
2. Energy Cost Savings (B$)	0.004	0.03	0.16	0.29	0.21	0.08
3. Carbon Reduction (MMTCE)	0.02	0.12	0.54	0.87	0.60	0.25

Projected benefits for the Glass Industry Vision were based on analysis of 15 active R&D projects addressed to improvements in energy efficiency and environmental performance of glass manufacturing processes. The table below identifies these projects, grouping them into separate targets including modeling/simulation, sensors/control, combustion, furnace technology, and glass composition/properties/finishing. It is estimated that these projects represent approximately 90% of the latest fiscal year's R&D budget. The FY 2003 budget for Glass Industry Vision is $4.6 million.

Energy consumption in the glass melting industry is dominated by the use of natural gas in melting furnaces. Four major industry segments use somewhat differing process equipment to produce container glass, flat glass, fiber glass, and pressed/blown glass. In the United States, approximately 380 furnaces currently produce 18.16 million tons of product annually; these furnaces range in size from pressed/blown specialty glass melters under 75 TPD capacity to flat/float glass melters of more than 550 TPD capacity.

Table 9. Summary of GPRA 2004 Benefits – Glass Industry Vision

Impact Target	Project/Spreadsheet Run File Name	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Modeling/ Simulation	Modeling of Glass Processes (Modeling.Glass.Processes.04)	0.61	4.42	2003/c
	Validation of Coupled Combustion Space/Glass Bath Furance Simulation (Coupled.Bath.Simulation.03)	0.53	7.11	2006/b
	Process Optimization for On-line Coating of Float Glass (glasscoating.04.new)	0.0	0.12	2005/b
	Diagnostics and Modeling of High Temperature Corrosion of Refractories (Diagnostics.Corrosion.Refractories.Furnaces.03)	1.24	10.30	2005/b
	Subtotal	**2.38**	**21.95**	na
Sensors/ Control	Molybdenum Disilicide Composites for Glass Sensors (MolyDisilicideComposites.Sensor.04)	0.24	0.71	2004/b
	Monitoring/Control of Alkali Volatization and Batch Carryover (controlalkalibatch.04.new)	0.35	3.46	2005/b
	Measurement and Control of Glass Feedstocks (controllibs.market1.04,controllibs.market2.04)	0.29	2.85	2005/b
	Advanced Process Control for Glass (Auto.Sideglass.Control.04)	0.75	4.45	2004/b
	Auto Glass Process Control (Auto.Glass.Process.Control.04)			
	Subtotal	**1.63**	**11.47**	na
Furnace Technology	High-Luminosity Low Nox Burner (High-Luminosity.LowNOx.Burner.04)	0.29	0.90	2003/b
	Integrated Batch Preheater (batchpreheatcontainer.04.new, batchpreheatflat.04.new,batchpreheatspecial.04.new)	0.85	8.41	2003/b
	Glass Furnace Combustion and Melting User Facility (User.Facility.04)	1.27	11.96	2005/b
	Subtotal	**2.41**	**21.27**	na
Glass Composi-tion/Properties/Finishing	Enhanced Cutting and Finishing of Handglass With a Laser (Laser.Cutting.ofGlass.04)	0.37	1.10	2003/b
	Integrated Ion Exchange System for High Strength Glass Products (Ion.Exchange.Strength.04)	1.02	9.70	2005/b
	Recovery/Recycling of In-house Glass Manufacturing Waste (glassrecycle.04.new)	0.30	2.68	2005/b
	Subtotal	**1.69**	**13.48**	na
	Grand Total	**8.12**	**68.17**	na

Total primary energy savings in 2010 are projected to be about 8 trillion Btu, approximately 74% lower than the GPRA submission for FY 2003 (31 trillion Btu). Year 2020 energy savings are projected to be 68 trillion Btu, approximately 14% lower than the GPRA submission for FY2003 (79 trillion Btu). For comparison, the year-2010 projected energy savings are 3% of MECS 1998 primary energy consumption in the glass industry (293 trillion Btu). Our year-2020 projected energy savings are 23% of MECS 1998 primary energy consumption in the glass industry.

Changes from the GPRA 2003 submission, which occur mostly in the near-term, are due to a change in the model. In addition, three projects have been removed from this year's submission.

5. Metal Casting Industry Vision

Table 10. Metal Casting Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	0.8	23	63	101	116	116
2. Energy Cost Savings B$/yr	0.03	0.11	0.31	0.53	0.61	0.62
3. Carbon Reduction (MMTCE)	0.02	0.47	1.19	1.83	2.10	2.08

Projected benefits for the Metal Casting Industry Vision were based on analysis of 29 active R&D projects to improve energy efficiency in metal casting processes. The table below identifies these projects, grouping them into separate targets areas. It is estimated that these projects represent approximately 83% of the $5.3 million FY 2003 budget the Metal Casting Industry Vision. Where appropriate, market penetration estimates took into account multiple projects addressing a particular target area. Also where appropriate, multi-phase projects were combined into one spreadsheet.

Energy consumption in the metal casting industry is dominated by the use of electricity and natural gas. Coal/coke also is used. An estimated 55% of energy used in metal casting processes is used in melting. Metal casters use a variety of furnace types including electric melting furnaces, electric arc furnaces, induction furnaces, fuel-fired furnaces and cupolas. Other energy intensive operations include molding and heat treating. The U.S. metal casting industry is diverse. Castings are produced from gray and ductile iron, steel, aluminum and aluminum-based alloys, copper, magnesium, zinc and other metals. The industry is composed of nearly 2,950 foundries and die casters manufacturing metal products using a variety of casting processes. The most common casting processes are sand casting, permanent mold casting, die casting and investment mold casting. The lost foam casting process, which has traditionally represented a small share of casting production, is seeing a rapid increases due to the deployment of research findings.

In prior years, 1994 baseline energy consumption was estimated at 200 Trillion Btu. In 1998, energy use in the foundry industry (NAICS code 3315) was 235 trillion Btu (Source: DOE/EIA 1998 MECS). If captive foundries are included, the estimated energy consumption for metal casting increases to 328 trillion Btu. The Metal Casting Industry of the Future is co-funding research to improve efficiency in the industry and to reduce energy consumption in metal casting operations. It is funding research in industry defined areas for manufacturing technologies, materials technologies, products and markets, and environmental technologies.

Total primary energy savings in 2010 are projected to be about 23.38 trillion Btu, approximately 32% less than the GPRA submission for FY 2003 (34.49 trillion Btu). Year 2020 energy savings for the FY 2004 portfolio are projected at about 101.01 trillion Btu, 25% greater than the GPRA submission for FY 2003 (75.34 trillion Btu). For comparison, the year-2020 projected energy savings are 50.5% of 1994 primary energy consumption in the metal casting industry (200 trillion Btu); 43% of the 1998 energy consumption; and 13% of an informal OIT baseline projection for 2010 (264 trillion Btu).

Changes from GPRA 2003 submissions are most significant in the 2010 time frame and 2020 time frame. This is due to several factors. The model used for GPRA 2004 applies a market penetration curve that is inversed when compared to 2003. In addition, reported energy savings for GPRA 2004 represent the delta between energy saved with and without OIT involvement. This measures the role of OIT in the projected energy savings.

Table 11. Summary of Project Runs – Metal Casting Industry Vision

Impact Target	Project Name	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Computer-based Modeling Tools	Development of computational fluid dynamics tool for modeling bead expansion in lost foam	0.05	0.59	2004/b
	Computer modeling of the mechanical performance of die casting dies	2.03	4.48	2005/a
Die Life Extension/Die Performance	Surface Engineered Coatings for Die Casting Dies	0.01	0.05	2004/b
	Improved Design, Operation and Durability of Shot Sleeves	0.01	0.05	2007/b
	Integration of RSP Tooling in die casting	0.48	5.42	2005/b
Materials properties and performance (molds, dies, and castings)	Development Program for Natural Aging Aluminum Alloys	0.15	0.37	2005/a
	Determination of Bulk Dimensional Variation in Castings	0.34	2.92	2005/b
	Grain refinement of Permanent mold cast copper base alloys	0.14	1.64	2006/b
	Creep resistant zinc alloy development	0.23	1.77	2005/b
	Investment shell cracking	0.08	0.81	2005/b
	Service performance of welded duplex stainless steel castings	0.01	0.07	2006/b
Thin Wall/High Strength castings	Thin wall cast iron	0.10	2.38	2007/b
	Clean, machinable thin walled gray and ductile iron casting	0.36	2.19	2004/b
Advanced casting methods	Lost Foam	6.15	10.23	2004/a
	Investigation of Heat Transfer at the Mold/Metal Interface in Permanent Mold-Casting of Light Alloys	0.10	2.61	2007/b

	Metallic Reinforcement of the squeeze casting process	0.11	1.24	2005/b
Machining; inclusions, porosity reduction	Advanced Steel Technology	2.21	4.70	2005/a
	Prevention of porosity formation and other effects of gaseous elements	0.13	1.64	2006/b
	Improvements in sand/mold/cor technology: effect on casting finish	0.40	4.99	2006/b
Energy guidelines; Emissions Reduction; Byproduct Reuse	Energy consumption in die casting operations	1.80	3.99	2005/a
	Metallic Recovery and Ferrous Melting Processes	0.05	0.17	2006/a
	Non-incineration treatment to reduce benzene emissions	5.42	10.48	2005/a
	Technical data to validate foundry byproducts in hot mix asphalt	0.01	.03	2006/a
Sensors	Sensors for die casting	0.24	2.35	2005/b
Steel Foundry Practices (e.g. gating, heat treating, process re-engineering)	Re-engineering casting production systems	0.10	0.73	2004/b
	Yield Improvement in Steel Castings	2.27	30.98	2006/b
	Heat Treatment procedure qualification for steel casting	0.17	0.35	2005/a
Die Casting Practices (e.g. gating, process control, die filling, etc)	Ultrahigh speed measurement of internal die cavity temperature for process control	0.18	2.58	2006/b
	Effect of externally solidified product on wave celerity	0.08	1.21	2006/b
	Grand Total	**23.41**	**101.02**	**na**

6. Steel Industry Vision

Table 12. Steel Industry Vision - QM Rollup

Item	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
1. Primary Energy Savings (TBtu)	2.8	43	145	212	143	39
2. Energy Cost Savings (B$)	0.01	0.12	0.44	0.62	0.40	0.11
3. Carbon Reduction (MMTCE)	0.05	0.93	3.57	6.52	5.26	1.6

The GPRA submission for the Steel Vision is based on analysis of 27 technologies related to enhancing the productivity, energy efficiency, and environmental performance of steel manufacturing processes (see table below). The Steel Team's FY 2003 budget is approximately $10.3 million. The projects listed below represent approximately 42% of the budget, compared to the 80% figure for the 24 projects analyzed for the GPRA 2002 submission.

The mission of the OIT Steel Program is to support pre-competitive, higher-risk technologies and processes through cost-shared public-private partnerships. Revolutionary ironmaking and steelmaking technologies that will benefit the industry as a whole are ideal candidates for DOE support because of their enormous potential payoff. The DOE Steel Program has devised a strategy to foster both revolutionary ironmaking and steelmaking projects and incremental improvements to existing processes, thereby addressing long-term goals without neglecting short-term needs. The Program has also expanded the industry's fundamental base of knowledge to optimize key processes and resource efficiency. Since 2001, the Steel Program has been redirecting its portfolio to focus more on revolutionary steelmaking concepts rather than incremental improvements to existing processes in order to achieve maximum energy savings. This transition in the Program's strategy should produce dramatic drops in steelmaking energy intensity over the long term.

Table 13. Summary of Project Runs – Steel Industry Vision

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Processes	Advanced Process Controls for Integrated Mills	12.6	5.1	2004/a
	Hot Oxygen Injection into the Blast Furnace	3.6	1.5	2004/a
	Quantifying the Thermal Behavior of Slags	1.0	7.7	2005/b
	Automated Steel Cleanliness Tool**	1.6	1.6	2005/a
	Magnetic Gate for Molten Metal Flow Control	1.1	0.5	2004/a
	QMST	0.2	1.2	2005/b
	Investigation of Deadman/ Hearth Region of Blast Furnace	0.8	19.8	2008/b
Combustion/ Environment	NO x Emission Reduction by Oscillating Combustion	2.1	0.8	2004/a
	Dilute Oxygen Combustion	2.1	14.5	2004/b
	Nitrogen Control in EAF Steelmaking by DRI Fines Inject	2.0	17.9	2005/b
	Quality Improvement of Waste Oxide Briquettes	0.3	10.1	2009/a
	Optical Sensor for EAF Post-Combustion Control	0.5	2.5	2004/b
	Optimization of Post-Combustion in Steelmaking	1.5	7.6	2004/b
	Sustainable Steelmaking Using Biomass and Waste Oxides	1.4	25.0	2007/b
Materials	Intermetallic Alloys For Steel	0.8	10.8	2006/b

	Improved Refractory Service Life and Recycling Refractory Materials	0.8	4.2	2004/b
	Development of Submerged Entry Nozzles that Resist Clogging	2.1	14.5	2004/b
Quality	Inclusion Optimization for Next Generation Steel Products	0.3	5.1	2007/b
	Laser-Assisted Arc Welding of Advanced HSS	0.9	2.0	2006/a
	Resistance Spot Welding for HSS	0.9	2.1	2006/a
	Electromagnetic Filtration of Molten Steel	0.6	14.0	2008/b
	Controlled Thermo-Mechanical Processing of Tubes and Pipes	0.6	4.0	2007/a
	Development of Steel Foam Materials and Structures	0.6	6.5	2006/b
	Clean Steels – Advancing the State of the Art	3.2	27.3	2005/b
	Formability of HSS steels	0.4	1.8	2004/b
	Fatigue/Crash Performance HSS	0.2	1.9	2006/b
	Hydrogen and Nitrogen Control in the Ladle and Casting	1.2	2.5	2006/a
	Total	**43.4**	**212.2**	

Total primary (counting electricity generation and transmission losses) energy savings in 2010 are projected to be 43.4 trillion Btu, compared to 70.8 trillion Btu in GPRA 2003. Year-2020 primary energy savings for the FY 2004 portfolio are projected at about 212.5 trillion Btu, compared to 151 trillion Btu last year. For comparison, 1998 primary energy consumption for the steel industry was 1.68 quads. The projected savings in year 2010 are approximately 2.5% of the projected baseline energy use in the industry.

Three projects analyzed for GPRA 2003 were dropped from this analysis (Non-Cr Passivation, PCI Coal Combustion Behavior, and Laser-Assisted Arc Welding) because they were completed. Six new steel projects were added to the GPRA 2004 analysis. None-the-less, the primary energy savings results for 2010 are lower than in last year's analysis because most of new projects will not be commercialized until 2007. The energy savings for 2020 are much higher than last year because the new projects will result in significantly higher savings. Additionally, the GPRA methodology has changed since last year, resulting in relatively lower energy savings for all of the projects. Using the new method, the GPRA result is the energy savings provided by the technology if OIT was not involved subtracted from the energy savings created with OIT's involvement.

The project entitled "NOx Emission Reduction by Oscillating Combustion" is being funded entirely by the steel team, even though it has potential benefits in a number of other industries. The only benefits counted in the steel team benefits roll-up are those directly attributable to steel industry applications.

There are no overlapping markets in any of the areas listed above. The Oscillating Combustion technology can be used in conjunction with Dilute Oxygen Combustion and does not represent an overlap.

The energy savings totals shown in the steel team benefits spreadsheet reflect only the projects actually analyzed, and have not been adjusted or normalized to reflect 100% of the budget.

7. Mining Industry Vision

Table 14. Mining Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	5.4	29	100	205	339	441
2. Energy Cost Savings (B$)	0.024	0.15	0.55	1.19	2.02	2.70
3. Carbon Reduction (MMTCE)	0.11	0.60	2.00	4.05	6.99	8.72

The Mining Industry of the Future program is currently funding 28 active R&D projects. Projected benefits for the Mining Industry Vision were based on analysis of 22 of these projects that address the metal, coal, and industrial mineral mining industry through improved safety, enhanced economic competitiveness, reduced energy consumption, and reduced environmental impacts. The table below lists the projects evaluated, merging them where appropriate. These projects represent approximately 76% of the $5.1 million FY 2003 budget for the Mining Industry Vision.

Where appropriate, market penetration rates were adjusted in projects within the same impact target area to correct for any potential overlap in energy savings. The two alternative fuel projects were combined into one energy benefits spreadsheet because they are part of a multiphase research effort.

Table 15. Summary of Project Runs – Mining Industry Vision

Impact Target	Spreadsheet Run File Name	Energy Savings 2010 (Trillion Btu)	Energy Savings 2020 (Trillion Btu)	Year of Intro/Market Selector
Materials	Cellular-03	0.34	2.74	2006/c
Sensors	Grader-03	0.15	0.90	2004/b
	Imaging-03	0.21	1.37	2004/c
	Geophone-03	3.09	22.90	2004/c
	Libs-03	2.84	19.62	2004/c
Alternative Fuels	Fuelcell-03 PhaseII-03	0.36	2.82	2005/c
Modeling	Comminution-03	1.72	11.74	2005/c
	Sag-03	1.44	9.36	2004/c
Communications	Communications-03	.012	0.84	2005/c
Processing	DMC-03	0.44	2.17	2004/b
	Analyzers-03	1.12	9.84	2005/b
	Byprodrecov-03	7.17	46.84	2004/b
	Flocculation-03	0.37	2.43	2004/c
	Anode	1.65	11.76	2006/c
	Screens	4.31	31.91	2007/c
Excavation	Cutting-03	0.05	0.33	2005/c
	Bolter-03	0.69	6.06	2005/b

	Robotics-03	0.26	1.71	2004/c
	blasting-03	3.01	18.65	2004/b
	Projectile-03	0.07	0.48	2006/c
	oilpro-03	0.02	0.16	2004/b
Total		**29.3**	**204.6**	

Total primary energy savings in 2010 are projected to be about 29.3 trillion Btu. Year 2020 energy savings for the FY 2004 portfolio are projected at about 204.6 trillion Btu. For comparison, the year-2010 projected energy savings are 2.6% of 2001 primary energy consumption in the mining industry (1,125 trillion Btu) and 2.4% of an informal OIT baseline projection for 2010 (1,230 trillion Btu). Our year-2020 projected energy savings are 18.2% of 2001 primary energy consumption in the mining industry and 16.6% of the OIT-calculated baseline for 2010 (DOE's Energy Information Administration does not collect mining industry data and no baseline projection for 2020 is available).

GPRA 2004-projected energy savings in 2010 are 61% lower than in 2003 GPRA (76.1 trillion Btu); GPRA 2004 shows year-2020 savings 22% higher than in GPRA 2003. Assumptions made for the 2003 GRRA were updated with more current data. Also, market penetration rates were updated with more current data. The percent of the 2004 budget captured in GPRA remained the same as GPRA 2003 at 80%. The table above indicates the year of market introduction assumed and the letter selector assigned to characterize the technology's market penetration in the spreadsheet model.

8. Petroleum Refining Industry Vision

Table 16. Petroleum Refining Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	4.2	34	146	175	125	119
2. Energy Cost Savings (B$)	0.01	0.12	0.56	0.72	0.55	0.56
3. Carbon Reduction (MMTCE)	0.06	0.52	2.24	2.83	2.26	2.29

Projected benefits for the Petroleum Refining Industry Vision were based on analysis of all active R&D projects (six projects) addressed to improvements in refinery operations. The table below identifies these projects, grouping them into separate targets including hydrotreating, pressure vessel integrity, facility emission control, improving hydrocarbon production process control, improving combustion efficiency, and substituting membrane separation for distillation. These projects represent the $2.80 million FY 2003 budget.

Table 17. Summary of Project Runs – Petroleum Refining Industry Vision

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Hydrotreating Energy Use	Broadening Enzyme Selectivity and Improving Activity for Biological Desulfurization and Upgrading of Petroleum Feedstocks	1.3	17.0	2005/c

Pressure Vessel Integrity	Assuring Mechanical Integrity of Refinery Equipment Through Global On_Stream Inspection	1.5	14.5	2005/b
Facility Emission Control	Hydrocarbon Leak Detector	1.7	17.0	2005/b
Process Control of hydrocarbons	Micro_GC Controller for Petrochemical Application	1.7	12.0	2004/b
Combustion Efficiency	Rotary Burner Demonstration	26.6	81.0	2004/b
Distillation Energy Use	Energy Saving Separation Technologies for the Petroleum Industry	1.6	33.3	2005/b
	Total	34.4	174.8	na

Total primary energy savings in 2010 are projected to be about 34.4 trillion Btu, approximately -5% of the GPRA petroleum Refining submission for FY 2002 (36.1 trillion Btu). Year 2020 energy savings for the FY 2002 portfolio are projected at about 175 trillion Btu, about a 26% increase of the GPRA submission for FY 2002 (139 trillion Btu). For comparison, the "1994 Manufacturing Energy Consumption Survey" (94MECS) lists the petroleum refining industry as consuming approximately 3.153 quads for combustion and power plus 3.110 quads in the form of fuels used as feedstocks. The largest energy-consuming operations in petroleum refining are atmospheric and vacuum distillation, hydrotreating, reforming, fluid catalytic cracking and catalytic hydrocracking.

Changes in primary energy savings from the GPRA 2003 submission are due to:

- changes in the methodology for calculating the impact - The new analyses measure only the energy saved as a result of technology acceleration
- changes in the technology class and year of entry - These changes were the result of discussions with industry experts during the Petroleum Portfolio review.
- changes in the unit energy impact - These changes were a result of the industry experts input and recognize the fact that four projects have impact that extends beyond the refining industry

9. Industrial Materials Crosscut

Table 18. Industrial Materials for the Future Program - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	2.8	19	90	280	407	393
2. Energy Cost Savings (B$)	0.003	0.048	0.28	0.94	1.29	1.18
3. Carbon Reduction (MMTCE)	0.01	0.21	1.18	3.71	4.84	4.14

The GPRA submission for the Industrial Materials of the Future (IMF) Program is based on a spreadsheet benefits analysis of technical innovations under development by 35 projects, which are listed in the table below. The portfolio consists of 29 new projects from a competitive solicitation in 2001 and 6 projects carried over from previous years. Research in the 29 new projects is being lead by three types of research organizations – universities (11 projects), federal laboratories (10 projects), and industry (8 projects). The six projects carried over from the FY2003 GPRA analysis include Intermetallics for Ethylene Cracking;

Intermetallic Alloy Development for the Steel Industry; Intermetallic Alloy Development for Heat Treat Carburization; Boiler Tubes; Infrared Aluminum Billets Forging; and Infrared Die Heating.

Most of the technologies under development have applications in multiple industries but the benefit estimates were typically based upon a single application of a technology. In a few instances multiple applications were considered. For example, three refractories projects have applications in both the glass and aluminum industries and thus have two listings in the table below.

The 35 projects represent about $7.232 million (53%) of IMF's $13.7 million FY2003 R&D budget. The energy savings totals shown in the IMF benefits spreadsheet reflect only the projects actually analyzed, and have not been adjusted or normalized to reflect 100% of the budget.

Table 19. Summary of Project Runs – Industrial Materials for the Future

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
H-Series Steel Alloy	Stronger and More Reliable Cast Austenitic Stainless Steel	0.8	31.9	2009/b
	Semi-Stochastic Algorithm for Optimizing Alloy Composition High-Temperature Austenitic Stainless Steels	0.1	2.8	2009/c
	Combinatorial Methods for Alloy Design and Optimization	0.1	1.2	2010/c
	Inverse Process Analysis for the Acquisition of Thermophysical Property Data	0.2	1.7	2005/c
	Ultrasonic Processing of Materials	0.0	0.1	2005/c
Cr-W(V) Steel Alloys	New Class of Fe-3Cr-W(V) Ferritic Steels	0.6	15.6	2008/b
	Fracture Toughness and Strength in a New Class of Bainitic Chromium-Tungsten Steels	0.1	3.1	2008/b
Coatings	High Density Infrared (HDI) Transient Liquid Coatings for Improved Wear and Corrosion Resistance	0.3	8.2	2008/b
	Advanced Composite Coatings	0.0	2.7	2012/c
	High Energy Density Coating of High Temperature Advanced Materials	0.0	0.2	2010/c
Carbon-Based Coatings	Ultrananocrystalline Diamond (UNCD) Coatings for SiC Multipurpose Mechanical Pumps	0.9	20.9	2008/b
Refractories	Novel Carbon Films for Next Generation Rotating Equipment	0.1	4.7	2009/b
	Ceramic and Refractory Components for Aluminum Melting and Casting (Aluminum Refractories)	0.1	3.4	2009/b
	Ceramic and Refractory Components for Aluminum Melting and Casting (Glass Refractories)	0.3	10.2	2008/b

	Modeling of Magnesia-Alumina Spinel Glass Tank Refractories	0.0	0.9	2008/b
	Advanced Nanoporous Composites for Industrial Heat Applications	0.0	0.4	2010/b
	High Density Infrared Surface Treatments of Refractories (Aluminum)	0.0	0.5	2009/b
	High Density Infrared Surface Treatments of Refractories (Glass)	0.0	0.9	2008/b
	Thermochemical Models and Databases for High Temperature Materials (Aluminum Refractories)	0.0	0.5	2009/b
	Thermochemical Models and Databases for High Temperature Materials (Glass Refractories)	0.0	0.9	2008/b
Corrosion-Resistant Materials	Stress-Assisted Corrosion in Boiler Tubes	0.5	13.7	2008/b
	Physical and Numerical Analysis of Extrusion Process for Production of Bi-Metallic Tubes	0.1	3.3	2009/b
	Co-Extrusion Technology for Tubes/Pipes	0.0	1.7	2009/b
Wear Resistant Materials	Virtual-Welded Joint Design Integrating Advanced Materials and Processing Technologies	0.5	13.8	2009/b
	Advanced Wear and Corrosion Resistant Systems through Laser Surface Alloying and Materials Simulation	0.0	0.4	2007/b
	New Class of Ultra-Hard Borides	0.4	5.4	2007/b
	Super Hard Materials	0.0	0.7	2010/b
Stand Alone – Process Materials	Novel Modified Zeolites for Energy Efficient Hydrocarbon Separations	1.3	38.1	2009/b
Stand Alone – Process Materials	Oxide-Dispersion-Strengthened Tubes for Ethylene	0.0	6.7	2014/b
Stand Alone – Chlor-Alkali Cell	Advanced Chlor-Alkali Technology	0.8	6.4	2010/c
Stand Alone – Tools & Dies	Advanced Tooling Alloys for Molds and Dies	0.1	5.6	2010/c
Stand Alone – Novel Processing	Ultrahigh Magnetic Field Processing of Materials	0.6	5.1	2007/c
Stand Alone - Ethylene cracking	Intermetallics for Ethylene Cracking	4.8	32.9	2004/c
Stand Alone - Steel casting; heat	Intermetallic Alloy Development for Steel	0.4	2.9	2005/c
Stand Alone - Steel - heat treating	Intermetallic Alloy Development for Heat Treating Carburization	3.7	21.8	2004/b
Stand Alone - Kraft	Boiler Tubes	1.7	9.6	2004/c
Stand Alone - Aluminum and titanium forging	Infrared Aluminum Billets Forging	0.1	0.5	2004/b

Stand Alone - Aluminum and steel die heating	Infrared Die Heating	0.1	0.9	2004/b
	Total	18.9	280.1	Na

Total primary energy savings in 2010 are projected to be 19 trillion Btu, about one fourth the GPRA submission for FY 2003 (74 trillion Btu). Year-2020 primary energy savings for the FY 2004 portfolio are projected to be about 280 trillion Btu, about one third more than the 207 trillion Btu result of the GPRA 2003 analysis. The year-2010 benefits are lower in this year's analysis because most of the projects are new and therefore have later commercial introduction years than last year's projects. Benefits are also lower in 2010 because changes made to the Impacts Model resulted in lower market penetration in the early years, especially for projects with commercial introductions around 2005. The year-2020 benefits are higher in this year's analysis because of the number of projects analyzed has increased from 12 to 35.

10. Sensors and Controls Crosscut

Table 20. Sensors and Controls Program - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	0.6	8	34	47	25	5
2. Energy Cost Savings (B$)	0.002	0.03	0.14	0.21	0.13	0.027
3. Carbon Reduction (MMTCE)	0.01	0.16	0.65	0.88	0.48	0.10

Projected benefits for the Sensors & Controls (S&C) Program Vision are based on analysis of 4 active R&D projects that are aimed to improve energy efficiency and environmental performance within the nine Industries of the Future (IOF) manufacturing sectors. The table below identifies these projects, grouping them into two separate targets: (1) sensors and measurement technologies and (2) control and optimization. It is estimated that these projects represent approximately 13% of the $3.8 million FY 2003 budget.

The worldwide markets for sensing technologies and for process controls are $15 billion and $26 billion a year, respectively, with the United States being the largest provider and single national market. The major share of both the sensor and the process control markets is in the manufacturing sectors targeted by the IOF Program. The high-volume use of sensor and control technologies in IOF sectors is based on the realization that significant resource/process efficiency and waste reduction can be achieved through intelligent process control using real-time measurement information. Critical to achieving the set targets of reduction in energy use and carbon emissions by the IOF vision industries is the development and delivery of sensor and control solutions for the many unmet needs as documented in the IOF technology roadmaps. The Sensors and Controls Program aims at delivering these needed solutions with broad applicability across multiple industry sectors, with a particular focus on high-risk and high-payoff technology research, development, and demonstration activities.

Table 21. Summary of Project Runs – Sensors and Controls Program

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Sensors and Measurement Technologies	Remote Material On-line Sensor	0.57	5.76	2005/b
	In-Situ, real-Time Measurement of Melt Constituents	0.94	8.29	2005/b
	Solid State Chemical Sensors for Monitoring Hydrogen	3.15	24.36	2005/b
Control and Optimization	Diagnosis and Control of Natural Gas Fired Furnaces via Flame Image Analysis	3.52	11.71	2006/a
	Total	**8.18**	**46.98**	na

Total primary energy savings in 2010 are projected to be about 8.18 trillion Btu, 10% less than the GPRA submission for FY 2003 (9.2 trillion Btu). Year 2020 energy savings for the FY 2004 portfolio are projected at about 46.98 trillion Btu, 28% greater than the GPRA submission for FY 2003 (36.8 trillion Btu).

The primary energy savings results for 2010 are lower than in last year's analysis because a change in the GPRA methodology, resulting in relatively lower energy savings for all of the projects. Using the new method, the GPRA result is the energy savings provided by the technology if OIT was not involved subtracted from the energy savings created with OIT's involvement.

Two of the ten project analyses were dropped for GPRA 2004 because they will be complete in FY02. These were the Thermal Imaging Control of Furnaces and Combustors and Cupola Furnace Control Systems. Four other projects (Tunable Diode Laser for Harsh Combustion Environments, On-line Measurement Using Laser-Based Ultrasonic System, Sensor Fusion for Intelligent Process Control, and Intelligent Extruder) were also dropped for this analysis because sufficient background data was not available. Additionally, their GPRA 2003 benefits were relatively minor as compared to the four projects in this year's analysis.

11. Combustion Crosscut

Table 22. Combustion Program - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	0	18	144	588	857	534
2. Energy Cost Savings (B$)	0.00	0.06	0.53	2.29	3.54	2.34
3. Carbon Reduction (MMTCE)	0.00	0.26	2.12	8.58	12.49	7.76

The GPRA submission for the Combustion Program is based on analysis of 3 projects (1) SuperBoiler: PM/TM Boiler Development and Demonstration, (2) Advanced, Integrated Process Heater/Burner System, and (3) Low NOx, Low Swirl Burner. The Combustion Program's FY 2003 budget is approximately $2 million, with the projects listed below representing approximately 80% of the budget.

This budget is considerably smaller than the $14.6 million FY2002 budget, due to the EERE reorganization, which transferred the Gasification project to the Biomass Program.

Table 23. Summary of Project Runs – Combustion Program

Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Super Boiler: PM/TM Boiler Development and Demonstration	13.7	503.3	2009/b
Advanced, Integrated Process Heater/Burner System	3.9	83.8	2007/b
Low NOx, Low Swirl Burner	0.06	0.06	2004/a
Total	**17.7**	**587.2**	

Total primary (counting electricity generation and transmission losses) energy savings in 2010 are projected to be 17.7 trillion Btu, compared to 34.2 trillion Btu in GPRA 2003. Year-2020 primary energy savings for the FY 2004 portfolio are projected at about 587.2 trillion Btu, compared to 105.8 trillion Btu last/year.

The primary energy savings results for 2010 are lower than in last year's analysis because a change in the GPRA methodology, resulting in relatively lower energy savings for all of the projects. Using the new method, the GPRA result is the energy savings provided by the technology if OIT was not involved subtracted from the energy savings created with OIT's involvement. Additionally, the GPRA energy savings for 2020 is significantly higher than last years due to a change in calculation for the Super Boiler project.

The Super Boiler is an improved gas-fired packaged boiler with high thermal efficiency and low emissions designed to replace existing boilers as they reach the end of their useful lifetimes. The technology is assumed to enter its market in 2009 with market penetration curve "b". The 2020 energy savings for this project is significantly higher than last year due to an error in previous year calculations. The SuperBoiler savings were calculated in past years using a 5% capacity factor (or 438 hours per year) whereas it should be a 50% capacity factor (or 4380 hours per year). Using the new capacity factor, therefore, increases the energy savings by a factor of 10.

The Integrated Process Heater/Burner System is for both retrofits and new advanced installation in the chemicals and petroleum industries. Market introduction in 2007 is assumed with a penetration curve "b" in the spreadsheet model. The Low NOx, Low Swirl project, added to the analysis this year, will optimize the low-swirl burner to capture the benefit of firing with partially reformed natural gas and with internal flue gas re-circulation (IFGR). Efforts will focus on designing and demonstrating a low-swirl burner with IFGR that can be scaled to large industrial boilers. Market introduction is planned for 2004, with market penetration curve "a".

B. Technical and Financial Assistance Planning Units

Two planning units – the Inventions and Innovation program and the NICE^3 program – have been removed from OIT due to reorganization since the completion of GPRA 2003. Therefore GPRA includes results for only two Technical and Financial Assistance planning units – the Industrial Analysis Center program and the Best Practices program.

The Industrial Analysis Center program and the Best Practices program were again assessed based on retrospective analysis of performance data accumulated over a period of years. Quality Metrics for these planning units assume that continuation of the programs will result in beneficial impacts proportional to documented experience at historical budget levels. These analyses assume no continuing contributions from prior program expenditures, but only assume that future expenditures will produce results proportionate to those reported for past expenditures.

1. Industrial Assessment Center (IAC) Program

Table 24. IAC Program - QM Estimation and Summary

Item	2004	2005	2006	2007	2010	2015	2020	2025	2030
1. Number of Assessment Days	750	750	750	750	750	750	750	750	750
2. Cumulative Number of Assessment Days Counted	750	1,500	2,250	3,000	5,250	5,250	5,250	5,250	5,250
3. Annual Energy Saved Per Audit (MBtu/Assessment-Year)	3686	3686	3686	3686	3686	3686	3686	3686	3686
4. Energy Saved From Assessments (TBtu)	2.76	5.53	8.29	11.06	19.35	19.35	19.35	19.35	19.35
5. IAC Assessment Replication Rate	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
6. Cumulative Number of Replications Counted	0	0	225	450	1,125	1,575	1,575	1,575	1,575
7. Annual Energy Saved From Replications (TBtu)	0	0	0.83	1.66	4.15	5.81	5.81	5.81	5.81
8. Number of Alumni Starting 25-Year Career	140	140	140	140	140	140	140	140	140
9. Number of New Energy Assessment Days Per Alumni-Year	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
10. Number of New Energy Assessments Performed	70	140	210	280	490	840	1,050	1,050	1,050
11. Cumulative Number of Alumni Energy Assessments	70	210	420	700	1,960	5,460	10,500	15,750	21,000
12. Number of Aged Energy Assessments Retired	0	0	0	0	0	350	700	1,050	1,050
13. Cumulative Number of Aged Energy Assessments Retired	0	0	0	0	0	1,050	3,850	8,400	13,650
14. Number of Alumni Energy Assessments Counted	70	210	420	700	1,960	4,410	6,650	7,350	7,350

15. Annual Energy Saved From Alumni Assessments (TBtu)	0.26	0.77	1.55	2.58	7.22	16.26	24.51	27.09	27.09
16. Additional Annual Energy Saved Per Website (TBtu/Year)	1	1	1	1	1	0	0	0	0
17. Annual Energy Saved From Website (TBtu)	1	2	3	4	7	7	7	7	7
18. Total IAC Annual Energy Saved (TBtu)	4.02	8.3	13.67	19.3	37.72	48.42	56.67	59.25	59.25
19. Energy Cost Savings (B$)	0.023	0.048	0.078	0.111	0.225	0.304	0.368	0.400	0.416
20. Carbon Reduction (MMTCE)	0.069	0.147	0.248	0.361	0.712	0.894	1.029	1.076	1.076

The Industrial Assessment Center (IAC) program benefits were supported by 20 years of actual assessment and implementation data. Energy savings were calculated and summed from four sources associated with the IAC program: (1) IAC energy assessments, (2) replication assessments within firms served by IAC, (3) assessments performed by IAC student alumni, and (4) IAC website-related energy savings.

Based on historical data on 10,525 industrial site assessments, the IAC program was assumed to result in the performance of 750 assessment days annually, each of which will save, on average, 3,686 million Btu (at source) per year during seven subsequent years over which credit was counted. After growing through year 2010, the resulting national energy savings attributed to this source levels off at 19.35 trillion Btu per year, because new assessments afterward merely replace the contributions of aged assessments no longer being counted (line 4).

Based on ORNL survey results, every ten IAC Assessments were assumed to result in three replication assessments at different sites within three years of performance. The cumulative number of replicated assessments (line 6) is 0.3 times the cumulative number of IAC assessments performed (line 2), delayed by three years. The same average energy savings per Assessment (3,686 million Btu per year) were assumed.

Estimation of the contribution of assessments (or other, equivalent professional services) performed by IAC student alumni were based on a rate of graduation across the program of 140 fully-trained students each year. It was assumed that every alumni performs 0.5 energy assessment each year for 15 years after leaving the IAC program and that each assessment subsequently saves 3,686 million Btu per year. The benefits of each energy assessment (or equivalent intervention) were assumed to persist for seven years, after which the aged energy assessment was "retired" for the purposes of this estimation. Subtracting the cumulative number of aged energy Assessments "retired" (line 13) from the cumulative number of Assessments performed (line 11) gives the number of alumni assessments counted in each year (line 14). Note that in the out-years (2020 and beyond) this source contributes more energy savings than does the continuing IAC assessment program itself.

Finally, based on a preliminary study by ORNL, the contributions of the IAC website were conservatively estimated to grow at the rate of 1 trillion Btu per year. The growth of this influence was assumed to continue for seven years beginning in 2004, so that the level of savings in 2010 was continued without further increase. This contribution was considered a placeholder pending the development of further website communication benchmark data. The FY 2003 budget request is $7.7 million.

Energy cost savings (line 19), carbon reduction (line 20), and other benefits are related to energy savings by projected fuel prices and emission coefficients given in the GPRA 2004 Data Call guidance.

2. Best Practices Program

OIT's Best Practices program is designed to change the ways industrial plant managers make decisions affecting energy use by motors, drives, pumps, compressed air, steam, combustion systems, process heat and other plant utilities. The FY 2003 budget request is $9.0 million. An overall program evaluation methodology is currently under development with the help of Oak Ridge National Laboratory. Elements and preliminary metrics are shown in Table 25. A discussion of these metrics follows. Significant changes in these approaches and metrics are likely as the program continues efforts to assess the impacts of various activities and approaches.

Dissemination of Best Practices information is achieved through a wide range of communication channels and covers a panoply of technical subjects. This analysis projects future benefits based on preliminary findings of an Oak Ridge National Laboratory study of program effects in 2001. Program activities are summarized into five main groups: Plantwide Assessments, Collaborative Technology Assessments, Training, Software Tools, and Publications. Impact estimation per implementation of best practices adopted by plants due to the influence of these five program activity areas are based upon actual program findings.

The basic methodology used in each of the five areas is very similar. First the reach is estimated. By this we mean the number of individuals touched by BestPractices information. This number is then scaled back to calculate the number of plants taking action due to this information dissemination. The scale-back factors include accounting for duplicate "touches" within the same company, the percent of companies actually taking action, and a reduction factor to discount program credit due to it being but one of multiple sources of influence. In the cases of Plantwide Assessments (PWAs) and Collaborative Technology Assessments (CTAs) no scale-back factor needed to be applied.

<u>Plantwide Assessments (PWAs) (Lines 1 - 8)</u>

Benefits for the Plantwide Assessments were calculated based on a three-year history. Of 23 such Plantwide Assessments conducted, 14 have completed recommendation reports. Based on these reports, potential energy savings are close to 0.4 trillion Btus per year per plant. Experience from the IAC Program indicates that roughly 50% of all recommendations are actually implemented. We expect this percent to be greater for the BestPractices program where the cost of the assessment is shared with industry, thus indicating a greater level of involvement. Nonetheless, the IAC implementation rate of 50% is being used until the BestPractices program is able to document a program-specific implementation rate. Hence the number assumed for energy savings by Plantwide Assessments is 0.2 trillion Btus per plant per year (line 7).

Table 25. Best Practices Program - QM Estimation and Summary

Item	2004	2005	2006	2007	2010	2015	2020	2025	2030
1. Plantwide Assessments (PWAs)	0	7	7	7	7	7	7	7	7
2. PWA Replication	0	0	35	35	35	35	35	35	35
3. Cumulative Number of PWA Implementations	0	7	49	91	217	427	637	847	1057

4. Plants Retired From Count Each Year	0	0	0	0	0	7	42	42	42
5. Cumulative Number of Plants Retired From Count	0	0	0	0	0	7	217	427	637
6. Net Number of Plants Still Counted	0	7	49	91	217	420	420	420	420
7. Annual Energy Saved Per Plantwide Implementation (TBtu/Plant-Year)	0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
8. Annual Energy Saved Through PWA Direct Implementation and Replication (TBtu)	0	1	10	18	43	84	84	84	84
9. Collaborative Technology Assessments (CTAs)	56	70	70	70	70	70	70	70	70
10. Cumulative CTAs	56	126	196	266	476	826	1176	1526	1876
11. CTA Plants Retired From Count Each Year	0.00	0.00	0.00	0.00	0.00	70.00	70.00	70.00	70.00
12. Cumulative Plants Retired From Counting	0.00	0.00	0.00	0.00	0.00	126.00	476.00	826.00	1176.00
13. Net CTA Plants Still Counted	56.00	126.00	196.00	266.00	476.00	700.00	700.00	700.00	700.00
14. Annual Energy Saved per CTA (TBtu/Plant-Year)	0.1186	0.1186	0.1186	0.1186	0.1186	0.1186	0.1186	0.1186	0.1186
15. Annual Energy Saved By CTAs (TBtu)	7	15	23	32	56	83	83	83	83
16. Individuals Reached Through Training	1770	2210	2210	2210	2210	2210	2210	2210	2210
17. Percent Representing Plants Taking Action	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
18. New Plants Affected Each Year	177	221	221	221	221	221	221	221	221
19. Cumulative Plants Affected	177	398	620	841	1505	2611	3717	4823	5930
20. Plants Retired From Count Each Year	0	0	0	0	0	221	221	221	221
21. Cumulative Plants Retired From Counting	0	0	0	0	0	398	1505	2611	3717
22. Net Plants Still Counted	177	398	620	841	1505	2213	2212	2212	2213
23. Average Energy Saved Per Plant Taking Action (TBtu/Plant-Year)	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
24. Annual Energy Saved By Training (TBtus)	9	20	32	43	77	113	113	113	113

25. Software Tools Distributed	17285	21606	21606	21606	21606	21606	21606	21606	21606
26. Percent Representing Plants Taking Action	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
27. New Plants Affected Each Year	1630	2037	2037	2037	2037	2037	2037	2037	2037
28. Cumulative Plants Affected	1630	3667	5704	7741	13851	24036	34220	44404	54589
29. Plants Retired From Count Each Year	0	0	0	0	0	2037	2037	2037	2037
30. Cumulative Plants Retired From Counting	0	0	0	0	0	3667	13851	24035	34220
31. Net Plants Still Counted	1630	3667	5704	7741	13851	20369	20369	20369	20369
32. Average Energy Saved Per Plant Taking Action (TBtu/Plant-Year)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
33. Annual Energy Saved By Software Tools Distribution (TBtus)	50	112	174	236	422	621	621	621	621
34. Publications Packets Distributed	73039	77606	77606	77606	77606	77606	77606	77606	77606
35. Percent Representing Plants Taking Action	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
36. New Plants Affected Each Year	2463	2617	2617	2617	2617	2617	2617	2617	2617
37. Cumulative Plants Affected	2463	5080	7697	10314	18164	31248	44332	57415	70499
38. Plants Retired From Count Each Year	0	0	0	0	0	2617	2617	2617	2617
39. Cumulative Plants Retired From Counting	0	0	0	0	0	5080	18164	31247	44331
40. Net Plants Still Counted	2463	5080	7697	10314	18164	26168	26168	26168	26168
41. Average Energy Saved Per Plant Taking Action (TBtu/Plant-Year)	1.87e_03	1.87e_03	1.87e_03	1.87e_03	1.87e_03	1.87e_03	1.87e_03	1.87e_03	1.87e_03
42. Annual Energy Saved By Publication Distribution (TBtus)	5	9	14	19	34	49	49	49	49
43. Total Annual Energy Saved By Best Practices (TBtu)	70	158	253	348	633	950	950	950	950
44. Energy Cost Savings (B$)	0.399	0.905	1.449	2.009	3.779	5.956	6.158	6.405	6.661
45. Carbon Reduction (MMTCE)	1.22	2.80	4.54	6.34	11.57	17.15	17.01	16.99	16.97

The number of Plantwide Assessments of 7 per year was projected by the Best Practices program staff based on assumed level funding (line 1). The annual energy saved directly by large plants due to PWA implementations (line 8) was calculated by multiplying the annual energy saved by each plant (line 7) times the net number of plants still counted (line 6). The net number of plants still counted (line 6) equals the cumulative number of plants having entered the program (line3) less the cumulative number of plants retired from the count (line 5). Plants are retired from the count after 10 years.

The number of PWA replications was calculated by estimating that each industry leading large showcase plant entering the program would influence five other large-size plants to replicate Best Practices with a two-year time delay. Current grantees are showing strong signs of replicating at as many as 20 other plants. The assumption used for this exercise is a replication factor of 5. Program staff are in the process of documenting actual replication rates for each Plantwide Assessment recipient.

Collaborative Targeted Assessments (CTAs) (Lines 9 - 15)

A critical tool of BestPractices is the Collaborative Technology Assessment (CTA) whereby DOE experts in industrial energy management are available to provide targeted, in-plant technical assistance to identify specific systems areas for improvement. CTAs are used both as a vehicle for training and as a prelude to conducting a Showcase Demonstration. Companies interested in hosting a Showcase Demonstration can request a walk-through assessment (one to three days) to identify opportunities for increased savings and productivity in industrial systems such as motors, steam, compressed air, pumping, and process heating.

Annual energy saved by implementations from CTA's (line 15) is calculated by multiplying the net number of CTAs still counted (line 13) times the median effect of all CTA's performed to date (line 14). Energy savings from a typical CTA (0.1186 TBtus) was derived from results reported in a spreadsheet entitled, "Activity Report for FY 2001" written by Oak Ridge National Laboratory. This energy savings number is a refinement of past estimates, and will continue to be refined as the program documents actual savings.

BestPractices plans to conduct 56 CTAs per year, with a 25% replication rate in the following year. Hence line 9 shows 56 CTAs in 2004 with 70 conducted in each subsequent year - 56 directly with the aid of DOE and 14 as a residual replication effect from the prior year's CTAs.

Training (Lines 16 - 24)

Training activities continue to play a key role in the strategy of BestPractices. Program managers have emphasized the "Train the Trainer" approach to help leverage limited federal dollars. The reach represented in this section of the program projections is based upon past precedent, and is therefore felt to be conservative. Actual reach should be several times the numbers indicated due to the multiplier effect of the "Train the Trainer" approach.

Line 16 shows the number of individuals trained in BestPractice sponsored workshops. Note that as with the CTAs, the second year shows a 25% increase in reach due to replication effect carryover from the preceding year. So each ensuing year will show 1770 individuals trained directly by DOE sponsored instructors and 440 additional individuals reached by those previously trained (this number will be tracked and may turn out to be much bigger).

Based upon studies conducted on past training activities in motors, pumps, and compressed air, it is assumed that the number of individuals trained must be reduced by 90% to represent the actual number plants where implementations of program Best Practice recommendations occur. This accomplished by multiplying Individuals Reached Through Training (line 16) by Percent Representing Plants Taking Action (line 17). Those plants are cumulated and retired after 10 years (lines 19 - 21) to arrive at Net

Plants Still Counted (line 22). Line 22 is then multiplied times the Average Energy Saved per Plant Taking Action - 0.051 Tbtus (line 23) - to calculate the Annual Energy Saved By Training (line 24). Line 23 is a weighted average of training in Pumps, Process Heat, Steam, Compressed Air, and Motors at both the individual company and the regional level.

Software Tools Distribution (Lines 25 - 33)

BestPractices has a variety of resources to help address a company's energy management needs and to help facilitate energy efficiency decision-making. BestPractices offers a range of software tools and databases that can assist a plant manager in making a self-assessment of a plant's steam, compressed air, motor, and process heating systems. Software tools include: AirMaster+, Airmaster+ Qualification, MotorMaster+ 3.0, Pumping System Assessment Tool (PSAT), PSAT Qualification, Steam System Scoping Tool, 3E Plus, Decision Tools for Industry, and ASDMaster: Adjustable Speed Drive Evaluation Methodology and Application. A new software tool geared toward Process Heating evaluation is due out in FY 2003.

Software Tools are distributed on CD-ROM or can be downloaded from the Internet. Although the program has a fairly good count of the number of software tools distributed, less is known about their actual use and impact. ORNL has been commissioned to explore the impact of software tool distribution. For purposes of this exercise it has been assumed that the average energy saved per plant taking an action due to software tool use is 0.03 TBtus per plant-year (line 32), or about 25% of the value of a CTA (line 14), and about 60% of the value of direct training (line 23).

The number of plants affected by the software distribution is estimated by taking the total number of pieces of software distributed (line 25), multiplying that number by the Percent Representing Plants Taking Action (line 26) to account for multiple copies going to different people at the same plant site and to account for those plants that are not ready or able to take action. A methodology analogous to that employed to derive the Training impact is then used to determine the Net Plants Still Counted (line 31), which is multiplied times Average Energy Savings (line 32) to calculate Annual Energy Savings due to Software Distribution (line 33).

Publication Dissemination (Lines 34 - 42)

BestPractices produces a variety of publications that are distributed in hardcopy or can be downloaded from the Internet. These publications include Technical Publications (e.g., Fact Sheets, Tip Sheets, Best Practices Resources, Market Assessments, Sourcebooks, and Repair Documents); Case Studies; and both the Energy Matters and OIT Times newsletters. This form of information dissemination has the broadest reach, but the least discernable direct impact on energy savings per exposure. The main purpose of most of these publications is really one of raising general awareness, interest and desire to learn more so that a plant manager might then investigate options more fully (perhaps by signing up for a training session or downloading and using a software tool).

The total number of exposure through publication dissemination is estimated to be over 73,000 in 2004 and increases to 77,600 because of the 25% replication effect (line 34). This number is multiplied by 3.4% (line 35) to estimate the total number of plants where information from the publications is applied (line 36). “Average Energy Saved per Plant Taking Action (TBtus / Plant-Year)” is shown in (line 41). This estimate of 1.87 Billion Btus (not trillion) is derived from a prior study conducted by Xenergy on the effect of motor publications and the Energy Matters newsletter. Annual Energy saved by the application of information in publications (line 42) is the product of Net Plants Still Counted (line 40) times the Average Energy Saved per Plant Taking Action (line 41).

Conclusion

Total Annual Energy Saved By Best Practices (Tbtus) (line 43) is a sum of the subtotals in the five areas previously outlined: PWA (line 8), CTAs (line 15), Training (line 24), Software Tools (line 33), and Publications (line 42). Lines 44 and 45 showing the Energy Cost Savings in Billions of Dollars and Carbon Reduction in MMTCE are derived by multiplying energy prices and carbon content factors for various fuels found in EIA *Annual Energy Outlook for 2002.*

Appendix A – FY 2004 Quality Metrics Final Summary Tables

GPRA 2004 PROJECTED PROGRAM BENEFITS - OFFICE OF INDUSTRIAL TECHNOLOGIES

Planning Element	YEAR 2010			YEAR 2020			YEAR 2030		
	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 2000 $)	Carbon Reduction (MMTCE)	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 2000 $)	Carbon Reduction (MMTCE)	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 2000 $)	Carbon Reduction (MMTCE)
Aluminum	22	0.09	0.55	199	1.01	5.25	144	0.80	3.21
Chemicals	67	0.23	1.14	787	2.89	12.61	410	2.11	7.44
Forest Products	14	0.04	0.15	267	0.67	2.74	371	1.06	3.80
Glass	8	0.03	0.12	68	0.29	0.87	18	0.08	0.25
Metal Casting	23	0.11	0.47	101	0.53	1.83	116	0.62	2.08
Steel	43	0.12	0.93	212	0.62	6.52	39	0.11	1.60
Mining	29	0.15	0.60	205	1.19	4.05	458	2.82	9.06
Petroleum Refining	34	0.12	0.52	175	0.72	2.83	119	0.56	2.29
IOF Specific S/T	*240*	*0.89*	*4.48*	*2014*	*7.92*	*36.7*	*1675*	*8.16*	*29.73*
Ind. Materials	19	0.05	0.21	280	0.94	3.71	393	1.18	4.14
Sensors & Controls	8	0.03	0.16	47	0.21	0.88	5	0.03	0.10
Combustion	18	0.06	0.26	587	2.29	8.58	534	2.34	7.76
C/C R&D Subtotal	*45*	*0.14*	*0.63*	*914*	*3.44*	*13.17*	*932*	*3.55*	*12*
IAC	38	0.23	0.71	57	0.37	1.03	59	0.42	1.08
Best Practices	633	3.78	11.57	949	6.16	17.01	949	6.66	16.97
TA Subtotal	*671*	*4.01*	*12.28*	*1006*	*6.53*	*18.04*	*1008*	*7.08*	*18.05*
IOF Crosscut S/T	*716*	*4.15*	*12.91*	*1920*	*9.97*	*31.21*	*1940*	*10.63*	*30.05*
Total	**956**	**5.04**	**17.39**	**3934**	**17.89**	**67.91**	**3615**	**18.79**	**59.78**

8-30-02

GPRA 2004 PROJECTED PROGRAM BENEFITS - OIT PLUS ELEMENTS NO LONGER IN OIT

Planning Element	YEAR 2010			YEAR 2020			YEAR 2030		
	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 2000 $)	Carbon Reduction (MMTCE)	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 2000 $)	Carbon Reduction (MMTCE)	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 2000 $)	Carbon Reduction (MMTCE)
Aluminum	22	0.09	0.55	199	1.01	5.25	144	0.80	3.21
Chemicals	67	0.23	1.14	787	2.89	12.61	410	2.11	7.44
Forest Products	14	0.04	0.15	267	0.67	2.74	371	1.06	3.80
B.L. Gasification*	26	0.13	0.54	621	3.50	12.08	966	5.67	18.79
Glass	8	0.03	0.12	68	0.29	0.87	18	0.08	0.25
Metal Casting	23	0.11	0.47	101	0.53	1.83	116	0.62	2.08
Steel	43	0.12	0.93	212	0.62	6.52	39	0.11	1.60
Mining	29	0.15	0.60	205	1.19	4.05	458	2.82	9.06
Bio-based Products*	76	0.13	0.45	948	2.66	10.05	1,832	8.69	28.22
Petroleum Refining	34	0.12	0.52	175	0.72	2.83	119	0.56	2.29
IOF Specific S/T	*342*	*1.15*	*5.47*	*3583*	*14.08*	*58.83*	*4473*	*22.52*	*76.74*
Ind. Materials	19	0.05	0.21	280	0.94	3.71	393	1.18	4.14
Sensors & Controls	8	0.03	0.16	47	0.21	0.88	5	0.03	0.10
Combustion	18	0.06	0.26	587	2.29	8.58	534	2.34	7.76
C/C R&D Subtotal	*45*	*0.14*	*0.63*	*914*	*3.44*	*13.17*	*932*	*3.55*	*12*
IAC	38	0.23	0.71	57	0.37	1.03	59	0.42	1.08
Inv. & Innov.*	207	1.07	3.95	2,190	13.78	42.72	1,558	11.03	30.61
NICE3*	5	0.02	0.08	45	0.22	0.76	38	0.19	0.62
Best Practices	633	3.78	11.57	949	6.16	17.01	949	6.66	16.97
TA Subtotal	*883*	*5.1*	*16.31*	*3241*	*20.53*	*61.52*	*2604*	*18.3*	*49.28*
IOF Crosscut S/T	*928*	*5.24*	*16.94*	*4155*	*23.97*	*74.69*	*3536*	*21.85*	*61.28*
Total	**1270**	**6.39**	**22.41**	**7738**	**38.05**	**133.52**	**8009**	**44.37**	**138.02**

*Shown only for comparison with earlier years. These planning elements will not be included in OIT GPRA 2004 portfolio.

GPRA 2004 QUALITY METRIC (QM) TRENDS – OIT PROGRAMS

Planning Element	2010 Energy Savings (TBtu)			2020 Energy Savings (TBtu)			2030 Energy Savings (TBtu)		
	'02 QM	'03 QM	'04 QM	'02 QM	'03 QM	'04 QM	'02 QM	'03 QM	'04 QM
Aluminum	78	76	22	238	194	199	479	365	144
Chemicals	112	233	67	592	786	787	1,221	1,652	410
Forest Products w/o B.L.	101	80	14	330	258	267	600	487	371
Glass	21	31	8	81	79	68	145	130	18
Metal Casting	18	35	23	71	75	101	130	117	116
Steel	59	71	43	178	151	212	263	219	39
Mining	28	76	29	118	167	205	204	239	458
Petroleum Ref.	120	36	34	466	122	175	767	234	119
IOF Specific S/T	*537*	*638*	*240*	*2074*	*1832*	*2014*	*3809*	*3443*	*1675*
Industrial Materials	22	74	19	86	207	280	146	362	393
Sensors & Controls	6	9	8	23	37	47	32	47	5
Combustion	21	34	18	103	106	587	190	183	534
C/C R&D Subtotal	*49*	*117*	*45*	*212*	*350*	*914*	*368*	*592*	*932*
IAC	44	40	38	61	58	57	62	59	59
Best Practices	175	169	633	338	438	949	501	707	949
TA Subtotal	*219*	*209*	*671*	*399*	*496*	*1006*	*563*	*766*	*1008*
IOF Crosscut S/T	*268*	*326*	*716*	*611*	*846*	*1920*	*931*	*1358*	*1940*
Total	805	964	956	2685	2678	3934	4740	4801	3615

Explanation of increases from GPRA 2003:

- Combustion – Analysts report that correction of an order-of-magnitude capacity factor error in GPRA 2003 worksheet for the Super Boiler project causes the increase.
- Best Practices – Increase is based upon a report by D. Jones, et. al., Oak Ridge National Laboratory, "Preliminary Estimation of Energy Management Metrics for the Best Practices Program," May 2002, with additional OIT staff assumptions.

GPRA 2004 QM TRENDS – OIT PLUS ELEMENTS NO LONGER IN OIT

Planning Element	2010 Energy Savings (TBtu)			2020 Energy Savings (TBtu)		
	2002 QM	2003 QM	2004 QM	2002 QM	2003 QM	2004 QM
Aluminum	78	76	22	238	194	199
Chemicals	112	233	67	592	786	787
Forest Products w/ B.L.*	277	187	40	1500	971	888
Forest Products w/o B.L.	101	80	14	330	258	267
Black Liquor Gasification*	176	107	26	1,170	713	621
Glass	21	31	8	81	79	68
Metal Casting	18	35	23	71	75	101
Steel	59	71	43	178	151	212
Mining	28	76	29	118	167	205
Bio-based Products*	15	189	76	100	545	948
Petroleum Ref.	120	36	34	466	122	175
IOF Specific S/T	*728*	*934*	*342*	*3344*	*3090*	*3583*
Industrial Materials	22	74	19	86	207	280
Sensors & Controls	6	9	8	23	37	47
Combustion	21	34	18	103	106	587
C/C R&D Subtotal	*49*	*117*	*45*	*212*	*350*	*914*
IAC	44	40	38	61	58	57
Inv. & Innov.*	21	112	207	108	283	2,190
NICE3*	9	45	5	44	121	45
Best Practices	175	169	633	338	438	949
TA Subtotal	*249*	*366*	*883*	*551*	*900*	*3241*
IOF Crosscut S/T	*298*	*483*	*928*	*763*	*1250*	*4155*
Total	1026	1417	1270	4107	4340	7738

*Planning elements not reported with OIT for GPRA 2004. These are included here only for comparison with prior years.

GPRA 2004 QUALITY METRIC (QM) TRENDS – % OF BUDGET REPRESENTED

Planning Element	% of Budget Represented			
	2001 QM	2002 QM	2003 QM	2004 QM
Aluminum	88	90	95	80
Chemicals	73	88	97	59
Forest Products	88	96	98	74
Glass	54	90	86	90
Metal Casting	52	81	95	83
Steel	45	60	80	42
Mining	42	70	80	76
Petroleum Ref.	63	90	86	100
Industrial Materials	70	60	75	53
Sensors & Controls	90	90	90	73
Combustion	na	na	60	80
IAC	na	na	na	na
Best Practices	na	na	na	na

Appendix B – Technology Impact Projections Model

A copy of the Excel-based Impact Projections Model spreadsheet system is available as a separate file called *GPRA 2004shell v5.3 06212002*.

Technology Impact Projections

The Technology Impact Projections model is used to estimate the potential security, economic, and environmental benefits resulting from research, development, and demonstration projects funded by the Office of Industrial Technologies (OIT). Benefit estimates are critical for evaluating projects and presenting the merits of both individual projects and the overall RD&D portfolio.

Proposers responding to a Solicitation or Request for Proposals should use the Technology Impact Projections model to estimate program benefits. Use of the model across all projects allows OIT to estimate the benefits of its projects in a consistent manner. The model allows you to enter key information about your proposed technology and its expected market, and then calculates the potential energy savings, cost savings, emission reductions and other project benefits.

Please provide your best estimate for each piece of information required to complete the spreadsheet (highlighted with light yellow shading). Be realistic about your estimates: if you are awarded a contract, you will be required to update this information annually. Note that not all inputs are necessarily applicable or available for all possible technologies. If you can only estimate the differential between the proposed new and the current state-of-the-art technology, reflect that in the spreadsheet by setting values for the current technology to “0". Also note that the Supplementary Table (“Additional Data” tab) only appears if non-zero values are entered for use of feedstocks, biomass, waste, or “other” energy forms. This table requests information on emission factors and costs for those energy forms.

Description

Provide an overview of the project/technology. This includes the project name, OITIS number (once project is funded), who prepared the estimates, program manager, planning unit, lab and industry contacts, and data sources.

Also provide a short summary of the technology upon which benefit estimates are based. Describe what constitutes a typical process unit for your technology, in terms of annual output (production capacity times duty factor). For simplicity, the analysis will assume that all units in the industry have the same capacity. A realistic, average, or typical unit capacity should be chosen, particularly for situations where the unit size may vary in different installations. By convention and to enable comparisons, units for the new technology and the current state-of-the-art should be equal in output capacity, even if, in reality, the new technology might have a different capacity for various reasons.

The new technology also might not be a physical item of hardware. Rather, it could be a process change, a computer model or control system, operational change or other non-physical technique. In such cases, a unit should be defined as the typical or average process or plant that would utilize the new technique. The annual energy inputs based on the expected energy consumption of the process or plant with the new technique would then be compared with annual energy consumption required by existing techniques.

Unit Inputs

Please provide key information on the performance of single installed units or applications of your technology. The performance of the new technology should be consistent with the performance goals in your proposal. For comparison, provide information on the performance of the best available technology for the application, not the average of all in-place technology units.

Energy Use

Please provide energy use per year for the new and conventional units, by fuel. Please also indicate the price of any feedstock, biomass, waste, and other fuels on the supplementary table (Additional Data tab). Prices for waste used as fuels may be negative, reflecting the avoided cost of conventional waste disposal.

Electricity - Includes direct electricity.
Natural Gas - Includes pipeline fuel natural gas and compressed natural gas.
Petroleum - Includes residual fuel, distillate fuel, and liquid petroleum gas.
Coal - Includes metallurgical coal, steam coal, and net coal coke imports.
Feedstock - Includes fossil fuels consumed in non-energy uses such as process feedstocks.
Biomass - Includes the use of biomass (for energy or as feedstock).
Wastes - Includes the use of fuels that are generated as wastes or process by-products. Examples of such fuels are refinery fuel gas, blast furnace gas, hog & bark fuel, and sewage sludge.
Other - Includes any fuels that may not be included in those listed above.
Total Primary Energy - Is calculated from individual energy inputs. Note that the primary equivalent of direct electricity consumption includes losses in electricity generation and distribution.

Energy use may be entered in physical units (e.g., billion cubic feet of natural gas) or primary units (trillion Btu). The exception is electricity use, which has to be entered as site energy consumption (either in billion kwh or trillion btu). Physical units is the default value for all energy use. To change to trillion btu, select the appropriate fuel (electricity, natural gas, etc.) and then select either physical units or trillion Btu from the pull down list.

Environmental

Environmental impacts of your new technology can generally be divided into impacts that are a direct result of energy savings and non-energy-savings-related emissions impacts. The energy-savings-related environmental emissions are calculated automatically by the spreadsheet from the energy savings (and fuel substitutions or use of biomass) and typical emissions factors for fossil fuels and electricity use. If your technology results in changes to consumption of feedstocks, biomass, wastes, or other fuels then you will need to enter appropriate emission factors for those fuels on the supplementary table.

Please provide estimates for non-combustion related emissions and non-energy-related waste production associated with the new and conventional technologies.

Other Greenhouse Emissions Displaced
Estimate of the amount of greenhouse emissions other than CO2, Nox, and VOCs if germane to your technology. These could include methane, perflourocarbons, or other gases. Identify which gas in the Description sheet.

Cost and Lifetime

Please provide rough estimates of the initial capital cost, operation and maintenance costs, non-energy variable costs, and lifetime associated with your technology new and old on a per-unit basis. Non-energy costs should include improvements to productivity that may not be captured in the O&M costs.

Market Inputs

To determine the potential impact of the new technology as it becomes adopted, it is necessary to estimate the total market for the technology, reduce that to the likely actual market, and estimate when and the rate at which the new technology will penetrate the market.

Total Market

The next step in projecting the overall potential impact of your technology is to identify the total market: the number of units that perform the same task as your proposed technology. Only the domestic U.S. market should be included. World market and export potential are important factors which may be considered separately, but this analysis is to estimate domestic energy and emissions reduction impacts.

Number of Installed Units in US Market
Please define that market as narrowly as possible: i.e. the smallest group of applications that covers all potential applications that you may have some data for. You may base your estimate on the energy use of the state-of-the-art technology and the energy use data provided in this package. Other potential data sources include OIT's Energy and Environmental Profile for the relevant industry, EIA's MECS data, or industry sources. Please provide a citation for the number of units in the comments section. Please also indicate for which year the data that you provided applies.

Annual Market Growth Rate
This should be based on an EIA or industry growth projection for the relevant industry. Please provide a citation for the growth rate in the comments section.

Market Share

Market share is a function of the potential accessible market share and the likely market share.

Potential Accessible Market Share
Please estimate the accessible market: the market that the new technology could reasonably access given technical, cost, and other limitations of the technology. For example, certain technologies may only be applicable to a certain scale of plant, certain temperature-range processes, certain types of existing equipment or subsystems, or only certain segments of the industry.

Likely Market Share
In some instances, in addition to technical and cost factors, your technology may compete with other new technology approaches, or with other companies for the market. Please estimate the likely market share. Use current market share information or base your estimate market share on the basis of the number of competitors in the market, assuming they are using different technologies not resulting from this project. This is different than the possibility of "copycats" which should not be considered as competing. That is, if others adopt essentially the same, or slightly modified, technology due to this new technology, that adoption was triggered by the project being described and that project should be "credited" with causing that trend. This is potentially the case for techniques where the intellectual property cannot be, or is not, protected and becomes general knowledge throughout the industry.

Savings Attributed to Program

In some instances a program may be developing a technology in conjunction with another OIT, EERE, or DOE program. If this is the case, please provide an estimate of the percentage of savings that is attributed to the program. The attribution percentage should be similar to the percentage of federal funds provided to the project by the program. A default value of 100% has been entered in the model.

Market Penetration

To understand how rapidly the potential impact of the technology may be felt, the market penetration of the technology must be projected. This is based on two estimates, the technology development and commercialization timeline, and the market penetration curve.

Technology Development & Commercialization Timeline
The commercial introduction of a technology normally occurs after a significant demonstration or operating prototype and after an adequate test and evaluation period along with allowances for the beginnings of production, dissemination of information, initial marketing and sales or other "start up" factors. To capture this lengthy

process, please indicate the timeline for developing and introducing the technology into the market. This includes the years for when an initial prototype, refined prototype, and commercial prototype of the technology has or will be completed and the year when the technology will be commercially introduced. An initial prototype is the first prototype of the technology. A refined prototype represents changes to the initial prototype but not a commercially scaled-up version.. A commercial prototype is commercial-scale version of the technology. Commercial introduction is when the first unit beyond the commercial prototype is operating. Prototype and commercial introduction years should be consistent with your technology development program plans. Please note that two values for a commercial introduction year are requested. One should reflect when the technology is projected to be introduced if the program proceeds as expected (With OIT case). The other should reflect when the technology would have entered the market if the program had not been involved (Without OIT case). If the technology would not have been commercially introduced without the program, then enter a year of 2050 for the Without OIT case. The difference in commercial introduction years for the With OIT and Without OIT cases is referred to as the acceleration period.

Market Penetration Curve (Technology Class)

New technologies normally penetrate a market following a familiar "s" curve, the lower end representing the above uncertainties overcome by "early adopters." The curve tails off at the far future where some may never adopt the new technology. Of importance is the major portion of the "s" curve where the new technology is penetrating the market and benefits are being reaped. The rate at which technologies penetrate their markets varies significantly: penetrations of heavy industrial technologies generally takes place over decades, while simple process or control changes can penetrate much more rapidly. The actual penetration rate varies due to many economic, environmental, competitive position, productivity, regulatory, and other factors.

To assist you, a large volume of actual penetration rates of past and present technologies were analyzed, normalized, and grouped into five classes based on a number of characteristics and criteria. In Table I, circle the class (column) which you believe your technology best fits for each characteristic (row). Note that the characteristics (rows) are relatively independent and a given technology will likely fit best in different classes for different characteristics. By examining the pattern, however, one can, based on best judgment and experience, select the most likely class (rate) at which the new technology may penetrate the market. This may be a "subjective average" of the circled best fits, or it may be that one or two characteristics are believed to so dominate future adoption decisions that a particular class of penetration rate is justified. There also may be "windows of opportunity" where significant replacements of existing equipment may be expected to occur at some point in the future for other reasons. The proposer should insert into the spread sheet the class of penetration rate believed most likely, all things considered, and provide a narrative of the rationale for selection if not obvious from Table I.

For additional assistance, Table II shows actual technologies and the class of their historical penetration rates. Comparison of the new technology, by analogy or similarity, with these examples provides additional insight into selecting the appropriate penetration rate that might be expected for the new technology.

Expenditure Inputs

The benefits of a project need to be assessed relative to its costs. Please provide information on the level of funding for the project by EERE, other government agencies, and the private sector for the appropriate years. This should be entered under the "With OIT" area on the expenditure inputs sheet. Nominal dollar values should be entered.

Background

Please provide calculations that support the information entered into the unit inputs and market inputs sheets.

Impact Projections

The spreadsheet, based on the unit performance, market size, commercial introduction, acceleration period, and penetration rate class, calculates the estimated benefits which the new technology may bring to the industry and to the nation. Annual, cumulative and lifetime benefits are calculated for energy savings, cost savings, and emission reductions.

Table I. Selecting the Market Penetration Rate Class

Characteristic	A	B	C	D	E
Time to Saturation (ts)	5 yrs	10 yrs	20 yrs	40 yrs	>40 yrs
Technology Factors					
Payback* discretionary	<<1 yrs	<1 yrs	1-3 yrs	3-5 yrs	>5 yrs
Payback* non-discretionary	<<1 yrs	< 1 yrs	1-2 yrs	2-3 yrs	>3 yrs
Equipment life	<5 yrs	5-15 yrs	15-25 yrs	25-40 yrs	>40 yrs
Equipment replacement	None	Minor	Unit operation	Plant section	Entire plant
Impact on product quality	++	++	++	+	O / -
Impact on plant productivity	++	++	++	+	O / -
Technology experience	New to US only	New to US only	New to industry	New	New
Industry Factors					
Growth (%p.a.)	>5%	>5%	2-5%	1-2%	<1%
Attitude to risk	open	open	cautious	conservative	averse
External Factors	forcing	forcing	driving	none	none
Gov't regulation					
Other					

* Payback is defined as capital outlay for new technology divided by savings before taxes and depreciation. In the case of Discretionary investments (i.e. replacements of existing equipment before the end of its economic life), capital outlay is total cost of new technology. In the case of non-discretionary investments (i.e. replacements of existing equipment at the end of its economic life and new installations), capital is the capital cost of the new technology - capital cost of current technology.

Table II. Examples

Class	A	B	C	D	E
Aluminum		Treatment of used cathode liners	Strip casting, VOC incinerators		
Chemicals	New series of dehydrogenation catalyst (incremental change)	CFCs -> HCFCs, incrementally improved catalysts, membrane-baed chlor-alkali	Polypropylene catalysts, solvent to water-based paints, PPE-based AN	Synthetic rubber & fibers	
Forest Products			Impulse drying, de-inking of waste newspaper	Kraft pulping, continuous paper machines	
Glass		Lubbers glass blowing, Pilkington float glass	Particulate control, regenerative melters, oxygenase in glass furnaces		
Metals Casting	New shop floor practice				
Petroleum	New series HDS catalysts	Alkylation gasoline	Thermal cracking, catalytic cracking	Residue gasification, flexicoking	
Steel	Improved EAF operating practice (e.g. modify electric/ burner heating cycle to minimize dust generation)	BOF steel making	Oxyfuel burners for steel, Level II reheat furnace controls, Continuous casting, particulate control on EAF, Hightop pressure blast furnace	Open hearth technology, EAF technology	
Other		Advanced refrigerator compressors, oxygen flash copper smelting, solvent extraction with liquid ion exchange	Fluegas desulfurization (coal-fired utilities), low Nox industrial burners, industrial gas turbines, ore beneficiation		Dry-kiln cement, industrial ceramic recuperators Industrial heat pumps