GPRA 2003 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

April 19, 2002

Table of Contents

- Overview

This report describes the results, calculations, and assumptions underlying the GPRA 2003 Quality Metrics results for all Planning Units within the Office of Industrial Technologies.

GPRA 2003 year-2010 total OIT program energy savings were 1.417 quads, which for comparison represents 3.6% of year-2010 baseline industrial energy consumption. The results are summarized in Table 1 below; details are provided in two tables included as *Appendix A*. Year 2020 energy savings were 4.34 quads, or 10.0% of 2020 baseline industrial energy consumption. Projected energy savings in 2030 reached 8.547 quads, or 17.8% of extrapolated baseline industrial energy consumption in 2030.

The year-2010 savings were 38% greater than the 1.026 quads projected in GPRA 2002. Year 2020 savings were 5.7% greater than the 4.107 quads projected in GPRA 2002. Year-2030 savings were 2.8% higher than the GPRA 2002 projection of 8.315 quads. The net study result of many individual analytical changes was thus an increase in the nearer-term impacts of the OIT programs. These changes are primarily the net effects of:

- refinements and evolving assumptions in the analytical approach regarding the impact of individual projects and Planning Units, and
- increase in the number of innovative technologies analyzed prospectively in the analysis from about 217 in GPRA 2002 to approximately 274 in GPRA 2003.

The greatest increases in year-2010 savings as compared to the previous GPRA study were found in Agriculture (0.174 quad), Chemicals (0.121 quad), Inventions & Innovation (0.103 quad), Industrial Materials (0.052 quad), and Mining (0.048 quad). The largest increase, in Agriculture energy savings, was due primarily to a change in the treatment of biomass energy for GPRA 2003. The energy content of biomass feedstock is no longer subtracted from the primary energy savings total as it was in the past, although the cost and any emissions associated with the use of biomass are included in the energy cost savings and emission reduction totals. The rationale for this change is that primary energy units derived from biomass, if unused by advanced technologies, would be largely unavailable as fuels elsewhere in the economy. This is the same approach generally used by other EERE programs including biofuels and biopower. Additionally, the number of Agriculture projects included increased from 6 to 11.

Chemicals energy savings approximately doubled, due primarily to the addition of 19 projects. Inventions & Innovations savings were calculated for the first time using the same OIT Impact Projections Model as was used for the R&D planning elements. Nineteen I&I Category 2 projects with some industrial applicability were included in the totals, and the overall effect was a dramatic increase in projected benefits. Industrial Materials is represented by a completely different set of projects in GPRA 2003, and the projected energy savings were about three times the results found in the FY2002 GPRA analysis. The substantially-improved Industrial Materials effort for GPRA 2003 was independently reviewed by Arthur D. Little, Inc. Year-2010 Mining energy savings increased by 172% due to the use of more current market data and the addition of two projects.

These increases were offset somewhat by significant decreases in Forest Products (-0.090 quad) and Petroleum Refining (-0.084 quad) as compared to the results of the previous study. The Forest Products results, that were critically reviewed by Arthur D. Little, Inc., were smaller primarily due to more conservative analytical assumptions used for the Biomass and Black Liquor Gasification program benefits analysis. In the coming year OIT plans to begin a reassessment of the potential impacts of this technology. The reduced savings projections for Petroleum Refining were due to the deletion of 5 projects and the addition of 1 project, as well as the use of some more conservative assumptions.

Table 1. Office of Industrial Technologies - GPRA 2003 QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	508	1,417	2,695	4,341	6,385	8,546
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 (%)	1.4	3.6	6.5	10.0	14.0	17.8
4. Energy Cost Savings (B$)	1.84	5.39	10.6	118.0	27.2	37.3
5. Carbon Reduction (MMTCE)	7.89	24.5	48.5	82.7	125	171

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

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

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.

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 2002 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.

Some methodological improvements should also be noted. Beginning with GPRA 2003, I&I is using a prospective portfolio approach to assessing future program impacts based on the commercial potential of actual technologies under development. NICE[3] began using this approach with GPRA 2002. Now, all of the R&D programs in OIT use this same bottom-up approach based upon the current project portfolio. Progress continues to be made in the percentage of program budgets that are directly represented in the analysis. The number of R&D projects has increased from 154 in GPRA 2001 to 214 in the GPRA 2002 report to 274 in the GPRA 2003 report. Gradual improvement in the quality and quantity of project-level impact projections has been made possible by an OIT-wide requirement – as part of the solicitation process – for Principal Investigators to provide data required for the GPRA project spreadsheet analysis.

A limited-distribution, four-volume set of notebooks containing 274 spreadsheets supporting the GPRA 2003 process is entitled, "GPRA 2003 Quality Metrics: Supporting Spreadsheets." This set of notebooks provides over 1,900 pages of supporting documentation for the R&D project analyses which form the primary basis for the GPRA 2003 results.

- Aluminum Industry Vision

Table 2. Aluminum Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	17	76	133	194	273	365
2. Energy Cost Savings (B$)	0.06	0.28	0.51	0.80	1.17	1.62
3. Carbon Reduction (MMTCE)	0.31	1.95	3.91	6.07	8.33	10.86

The GPRA submission for the Aluminum Vision is based on a number of technologies related to improving the energy efficiency and environmental performance of primary and secondary aluminum production, enhancing recycling, and improving forming processes. Specifically, the table below identifies 21 projects that were analyzed. It is estimated that these projects represent about 95% of the Aluminum Team's $8.103 million FY 2002 budget.

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	3.1	13.2	2008/c
	Non-Consumable Anode For Electrowinning	1.5	6.0	2009/c
	Potlining Additives	3.4	6.9	2003/c
	Intelligent Potroom Operation	0.3	0.5	2004/b
	Low-Temperature Smelt, Wetted Cathode Cell	17.7	42.1	2007/d
	Carbothermic Reduction	6.1	12.2	2008/d
Secondary Aluminum Production	Vertical Flotation Melter and Scrap Dryer	2.6	9.8	2003/c
	High-Efficiency, Low-Dross Combustion System	0.8	1.5	2003/b
	Reduced Oxidative Melt Loss	4.8	12.5	2005/b
	Energy Eff Isothermal Melting	3.6	13.9	2006/c
	Energy Efficiency in Al Melting	2.9	9.1	2005/b
Recycling	Recycling Aluminum Saltcake	2.3	7.2	2004/c

	Processing of Aluminum Wastes	4.0	9.0	2004/c
Forming	Superior Aluminum Extrusions	0.7	3.0	2006/b
	Modeling Optimization DC Casting/Ingot Cracking	4.9	8.1	2005/a
	Textures in Strip-Cast Al Alloys	4.1	10.4	2003/c
	Spray Rolling	6.9	12.5	2004/d
	Continuous Cast Al Sheet	0.7	3.0	2007/c
	Plastic Deformation Processing	0.1	0.5	2005/c
	Coolant Characteristics	0.1	0.3	2005/b
	Rolling Process Design Tool	5.5	12.6	2006/a
	Grand Total	76.1	194.3	na

Total primary (counting electricity generation and transmission losses) energy savings in 2010 are projected to be 76.1 trillion Btu, close to the GPRA submission for FY 2002 (78.2 trillion Btu). Year-2020 primary energy savings for the FY 2003 portfolio are projected at about 194 trillion Btu. For comparison, 1994 primary energy consumption for the aluminum industry was 712 trillion Btu (approximately 10% of which is for alumina refining, 65% for primary aluminum smelting, and the remaining 25% split between secondary aluminum melting and semi-fabrication).

Six of the projects are new for FY 2003: Energy Efficient Isothermal Melting, Continuous Cast Aluminum Sheet, Energy Efficiency in Aluminum Melting, Plastic Deformation Processing, Coolant Characteristics and Control, and Rolling Design Tool. Three projects (Advanced Retrofit Cell, Wettable Ceramic-Based Cathodes, and Spent Potliner to Useful Products) that were part of the GPRA 2002 submission have been completed (or on hold) and have not been included in the GPRA 2003 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 2002 due to the large potential impact of two of the three projects that were in last year's analysis but are not in this year's analysis. In addition, the market potentials of technologies being developed in three other projects (Reduced Oxidative Melt Loss, Processing of Aluminum Wastes, and Spray Rolling) were lower than the potentials used last year, reducing the projected savings for these projects.

- Chemicals Industry Vision

Table 4. Chemicals Industry Vison - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	96	233	458	786	1,195	1,653
2. Energy Cost Savings (B$)	0.29	0.73	1.49	2.68	4.34	6.37
3. Carbon Reduction (MMTCE)	1.66	4.05	7.99	13.86	21.27	29.89

Projected benefits for the Chemical Industry Vision were based on analysis of 34 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 degradation, ethylene production, other production, gas separation, membrane construction, and waste recovery. It is estimated that the current funding for these projects represents about 95% of the $14.458 million FY 2002 Chemical Industry Vision budget.

Table 5. Summary of Project Runs – Chemicals Industry Vision

Impact Target	Project/Spreadsheet Run File Name	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Material Degradation	Alloy Selection System/ASSET (asset.03)	36.3	113.0	2004/c
	Mixed Solvent Corrosion (alloy.corrosion.model.03)			
	Corrosion Monitoring System (corrosion.monitoring.03)	16.8	52.1	2004/c
	Alloys for Ethylene Production (intermetalics.ethylene.crackers.03)	30.4	107.0	2005/c
	Metal Dusting Phenomenon (metal.dusting.03)	0.04	0.13	2005/c
Chemical Synthesis	Oxidative Cracking of Hydrocarbons (selectcat.03)	18.3	73.2	2004/c
	Oxidative Olefin Reactor (oxidativeolefin.03)			
	High Throughput Catalyst Screening (highthrucatalyst.03.new)			

	Selective Oxidation of Aromatic Compounds (directoxida.03)	3.5	9.7	2009/d
	Catalytic Hydrogenation Retrofit Reactor (hydrogenation.retrofit.reactor.03)	0.07	0.20	2003/c
	Silicones From Sand (sandsilicones.03.new)	1.5	9.6	2009/c
	Advanced Autothermal Reformer (autothermal.03)	4.7	18.7	2002/c
	Short Contact Time Reactor (shortcontactreactor.03.new)			
	Nanoscale Catalysts (nanoscale.03)	1.4	1.99	2003/a
	Alkane Functionalization Catalysts (alkane.catalysis.03)	2.1	11.5	2007/c
Separations	Sorbents for Gas Separation (advanced.acorbents.03)	1.3	3.3	2002/c
	Membranes for p-Xylene Separation (advmat.03)	11.1	49.3	2003/c
	Mesoporous Membranes for Olefin Separations (mesopormembrane.03.new)	5.3	25.1	2005/c
	Membrane Module Tubesheet (membrane.module.epoxy.03)	16.8	52.4	2004/c
	Separation of Hydrogen/Light Hydrocarbons (seplighthc.03.new)	1.2	4.2	2005/c
	Olefin Recovery From Chemical Waste Streams (olefinsep.03)	9.0	23.7	2001/c
	Electrodeionization for Product Purification (electrodion.03.new)	1.53	4.10	2003/c
	Purification Process for PTA (pta.purification)	0.6	2.6	2006/c
	PSA for Product Recovery (psawasterecovery)(psawasterecovery2)	4.9	28.2	2002/c
	Membranes for Corrosive Reactions (membranes.oxidative.reactions a)(membranes.oxidative.reactions b)	1.3	6.5	2007/c
Design and Optimization Tools	Solution Crystallization Modeling Tools (crystallizer.optimization)	1.4	6.7	2007/c
	Multi-phase Computational Fluid Dynamics (CFD) (cfdrollup1)	4.5	9.5	2003/b
	Molecular Simulation for the Chemical Industry			

	Reaction Engineering Workbench			
	Distillation Column Modeling Tools (distillation.column.model)	12.8	46.1	2007/c
Process Engineering	Intelligent Extruder (intellextruder.03.new)	8.8	15.0	2003/b
	Enhanced Heat Exchangers for Process Heaters (dimpletube.process.heaters)	5.8	13.0	2004/b
	Ethylene Process Design Optimization (ethylene.process.03.new)	6.9	23.3	2004/b
Chemical Measurement	Accelerated Characterization of Polymer Properties (microanalysis.polymer.properties)	0.8	7.9	2008/b
Biological Processes	Non-Aqueous Enzymes	24.4	67.9	2005/d
Total		233.4	786.0	

Rev. 10/30/01

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 233 trillion Btu, approximately double the GPRA submission for FY 2002 (112 trillion Btu). Year 2020 energy savings for the FY 2003 portfolio are projected at about 786 trillion Btu, which is about 20% more than the GRPA submission for FY 2002. For comparison, year 2010 projected energy savings are about 3.4% of 2000 energy use in the chemicals industry (6,064 trillion Btu).

Changes from the GPRA 2002 submission are due to the addition of 18 projects and the deletion of 3 projects. More of an increase is shown in 2010 due to changes in the model which now allow units adopted prior to 2005 to be included in the total.

- Forest Products Industry Vision

Table 6. Forest Products Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	32	187	477	971	1,703	2,397
2. Energy Cost Savings (B$)	0.193	0.905	2.264	4.873	8.317	11.409
3. Carbon Reduction (MMTCE)	0.76	4.35	11.12	24.14	42.42	59.94

Projected benefits for the Forest Products Industry Vision were based on analysis of 56 of 60 active R&D projects funded by the program in FY 2002. The table below identifies these projects, grouping them into separate targets including Raw Materials, Wood Preparation, Pulping and Bleaching, Chemical Recovery/Powerhouse, Papermaking, and Recycle/Recovery. It is estimated that these projects represent over 98% of the FY 2002 budget for active research projects in the Forest Products IOF. The total FY 2002 budget for Forest Products Industry Vision is $11.827 million.

The data collection sheets used to run the OIT Impacts Model were filled out by the Principal Investigators (PIs). The PI's were given DOE-EIA 1994 MECS data and industry data for forest products to assist in their assumptions. Each PI's submission was reviewed to ensure reasonable and realistic assumptions. In a few cases adjustments were made to PI assumptions and calculations.

As in the GPRA 2002 submission, the benefits for the Forest Products Industry Vision include the projected impacts of the Biomass and Black Liquor Gasification Demonstration Initiative, even though this project is carried in the OIT Combustion Program budget in FY 2001 and FY 2002. It is the data for the initiative as a whole that is included in the Forest Products GPRA roll-up, rather than the benefits estimated for the individual, enabling research projects being funded by the Forest Products Vision in FY 2002. Because the initiative represents such a large portion of the impacts of Forest Products IOF research, it has been shown as a break-out in the GPRA roll-up.

The energy savings for all projects *except* the gasification initiative were multiplied by 20% in order to adjust for unaccounted-for overlap in the markets of competing technologies, and also to account for the fact that only a fraction of the technologies under investigation will ultimately be commercialized. A major reassessment of this methodology is currently underway with the DOE Idaho Operations Office based upon industry experience in the past. A reassessment of the potential impact of biomass and black liquor gasification technologies is also planned.

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

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Raw Materials	Sustainability of High Intensity Forest Management	0.078	0.344	2003/c

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
	Molecular Physiology of Nitrogen Allocation	0.042	0.142	2010/d
	Search for Genes to Accelerate Pine Development	0.078	0.344	2003/c
	Nutrient Limitations in Intensively Managed Southern Pine	0.078	0.344	2003/c
	Environmental Influences on Wood Chemistry and Density of Populus & Loblolly Pine	0	8.86	2015/d
	Dominant Negative Mutations of Floral Genes	0	8.86	2015/d
	Genetic Augmentation of Syringyl Lignin in Low-lignin Aspen Trees	3.46	11.8	2012/d
	Quantifying and Predicting Wood Quality of Loblolly and Slash Pine Under Intensive Forest Management	7.18	22.7	2005/d
	Exploiting Genetic Variation of Fiber Components and Morphology in Juvenile Pine	0.198	0.628	2005/d
Wood Products/ Preparation	Microwave Pretreatment for Rapid Wood Drying	0.281	1.71	2006/c
	Commercial Demonstration of Wood Recovery, Recycling and Value Adding Technologies	0.103	0.221	2003/c
	Rapid, Low Temperature Electron X-Ray & Gamma Beam Curable Resins	0.0291	0.265	2010/c
	Control of Emissions from Wood Burners and Dryers	1.68	3.35	2002/b
	Fast Curing of Composite Wood Products	2.87	3.88	2004/a
	Wireless Microwave Wood Moisture Measurement System for Wood Drying Kilns	1.72	6.91	2005/b
Pulping and Bleaching	Higher Selectivity Oxygen Delignification	2.18	2.96	2003/a
	Decontamination of Process Streams Through Electrohydraulic Discharge	0.301	0.332	2003/a
	Mill Biobleaching Technologies	1.12	5.1	2003/c

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
	Water Recycling/Removal Using Hydrogels	0.805	3.66	2003/c
	High Selectivity Oxygen Delignification	0.989	1.99	2004/c
	NPE Removal Using Mesoporous Supports	2.28	16.2	2008/c
	Bubble Size Control for Oxygen Bleaching	0.421	1.91	2003/c
	Increasing Yield of Kraft Cooks Using Microwaves	0.503	3.07	2006/c
	Corrosion in Kraft Digesters	0.0845	0.281	2002/c
	Novel Pulping Technology: Directed Green Liquor Utilization (D-Glu) Pulping	0.664	4.65	2007/b
	Soft Sensing and Diagnosis for Continuous Digesters	0.228	0.462	2005/c
Chemical Recovery/ Powerhouse	Biomass and Black Liquor Gasification Initiative	107	713	2008/c
	Methane de-NOX	1.01	4.41	2003/c
	Intermediate-sized, Entrained Particles	12.2	15.2	2002/a
	Improved Recovery Boiler Performance Through Control of Combustion, Sulfur & Alkali Chemistry	0.861	4.56	2005/c
	Use of Borate Autocausticizing to Supplement Lime Kiln and Causticizing Capacities	1.60	2.48	2001/b
	Monitoring Corrosion and Erosion in Recovery Boiler Tubing (Guided Acoustic Wave Monitoring)	1.68	3.39	2003/c
	CFD Modeling, Shape Optimization and Feasibility Testing of Advanced Black Liquor Nozzle Designs for Improved Energy Efficiency	4.66	14.2	2004/b
	Laser Sensors for On-Line Monitoring of Carryover in Recovery Boilers	0.2	0.403	2002/c
	Development of Corrosion Resistant Chromium Rich Alloys for Gasifier & Kraft Recovery Boiler Applications*	*	*	NA

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
	Evaluation of Ceramic Coating for Protection of Piping in High-Temperature, High-Pressure Black Liquor Gasification*	*	*	2008/c
	Control of Soluble Scale Fouling in Concentrators*	*	*	2002/c
	Catalysts for the Destruction of Tars in Gasification*	*	*	2004/c
	Development of Materials for Gasification*	*	*	2004/c
Papermaking	Plasma Technologies for VOCs	0.284	0.350	2004/a
	Uniform Web Drying Using Microwaves	0.264	0.661	2003/b
	3D Characterization of the Structure of Paper	2.61	3.25	2002/a
	Multiport Cylinder Dryers	0.916	3.69	2005/b
	The Lateral Corrugator	1.14	5.14	2006/b
	Improving Dryer and Press Efficiencies Through Combustion of Hydrocarbon Emissions	5.30	19.4	2005/b
	Laboratory Development of a High Capacity Gas-Fired Paper Dryer	0.658	3.32	2004/c
	Proprietary Feasibility Study of a Continuous Process for Displacement Dewatering	4.12	22.9	2005/c
	Acoustic Foils for Enhanced Dewatering and Formation	0.324	1.26	2005/c
	Non-Contact Laser Acoustic Sensor & Contactless Monitoring of Paper	0.227	0.925	2002/c
	On-Line Fluidics Controlled Headbox	2.93	12.0	2002/c
	Prototype ESA System	0.248	1.13	2003/c
Recycle/Recovery	Use of Residual Solids for Concrete	0.881	2.9	2008/d
	Cationic Pressure Sensative Adhesives	0.966	3.51	2001/c
	Surfactant Spray to Improve Flotation Deinking	8.34	16.8	2004/c

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
	Mechatronic Control of Waste Paper Sorting	0.01	0.02	2004/c
	Screenable Pressure Sensitive Adhesives	0.125	0.356	2004/b
TOTAL		**186.67**	**970.59**	

12/12/01 * Data not included in rollup: part of the Biomass and Black Liquor Gasification Initiative

Total primary energy savings in 2010 are projected to be about 187 trillion Btu, about a 32% decrease from the GPRA submission for FY 2002 (277 trillion Btu). Year 2020 energy savings for the FY 2002 portfolio are projected at about 971 trillion Btu, about a 35% decrease from the GPRA submission for FY 2001 (1,500 trillion Btu).

The number of projects assessed in FY03 increased to 56 from 55 in FY2002. Changes in the GPRA 2003 results are due to the use (in some cases) of more conservative unit energy savings estimates, more conservative market sizes, more conservative assumptions about the speed of market penetration in some of these markets, and the use of different assumptions about the date of market introduction for the technologies.

The Biomass and Black Liquor Gasification Initiative makes up 57% (107 trillion Btu) of the estimated energy savings for the program in FY2010 and almost 73% (713 trillion Btu) in 2020 after more units are deployed. This project is expected to have a large impact on energy use in the industry due to the fact that black liquor and biomass gasification in combined cycle configuration can generate up to 300% more power from the same feedstock input than a traditional Tomlinson recovery boiler system with a combination boiler and steam turbine. The successful widespread commercialization of this technology could make the pulp and paper industry a net power generator. Other projects in the program portfolio are projected to save 80 trillion Btu in 2010 and 258 trillion Btu in 2020 (compared to 101 trillion Btu and 330 Btu in the GPRA 2002 analysis).

- Glass Industry Vision

Table 8. Glass Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	15	31	54	79	106	130
2. Energy Cost Savings (B$)	0.051	0.112	0.200	0.308	0.424	0.542
3. Carbon Reduction (C)	0.26	0.56	0.99	1.51	2.03	2.52

(MMTCE)						

Projected benefits for the Glass Industry Vision were based on analysis of 18 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 86% of the FY 2003 R&D budget. The FY 2002 budget for Glass Industry Vision is $4.572 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. The strong trend towards the use of oxy-fuel firing in order to reduce NO_x emissions and increase plant output has improved energy productivity in glass making. Several projects are aimed to accelerate and enhance the energy savings associated with this trend by overcoming continuing technology barriers.

Table 9. Summary of Project Runs – 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.03)	3.22	6.97	2002/d
	Validation of Coupled Combustion Space/Glass Bath Furance Simulation (Coupled.Bath.Simulation.03)	1.44	5.04	2005/c
	Advanced Combustion Space Models (Advanced.Combustion.Space.Models.03)			
	Process Optimization for On-line Coating of Float Glass (glasscoating.03.new)	0.12	0.28	2004/b
	Diagnostics and Modeling of High Temperature Corrosion of Refractories (Diagnostics.Corrosion.Refractories.Furnaces.03)	3.00	9.24	2004/c
	Subtotal	**7.78**	**21.53**	na
Sensors/ Control	On-line Sensor System for Monitoring Cure of Coatings (Sensor.Coating.OpticalFibers.03)	5.86	10.60	2002/b
	Molybdenum Disilicide Composites for Glass Sensors (MolyDisilicideComposites.Sensor.03)	0.56	1.52	2003/c

	Monitoring/Control of Alkali Volatization and Batch Carryover (controlalkalibatch.03.new)	1.21	4.04	2005/b
	Measurement and Control of Glass Feedstocks (controllibs.market1.03,controllibs.market2.03)	0.9	3.5	2005/b
	Advanced Process Control for Glass (Auto.Sideglass.Control.03)	1.22	3.81	2004/c
	Auto Glass Process Control (Auto.Glass.Process.Control.03)			
	Subtotal	**9.75**	**23.47**	na
Furnace Technology	High-Luminosity Low Nox Burner (High-Luminosity.LowNOx.Burner.03)	2.00	2.76	2001/b
	Integrated Batch Preheater (batchpreheatcontainer.03.new, batchpreheatflat.03.new,batchpreheatspecial.03.new)	2.63	7.31	2003/c
	Improved Refractories for Glass (Improved.Refractories.03)	0.93	2.20	2002/c
	Glass Furnace Combustion and Melting User Facility (User.Facility.03)	3.00	9.23	2004/c
	Subtotal	**8.56**	**21.5**	na
Glass Composition/Properties/Finishing	Enhanced Cutting and Finishing of Handglass With a Laser (Laser.Cutting.ofGlass.03)	1.07	2.56	2002/c
	Integrated Ion Exchange System for High Strength Glass Products (Ion.Exchange.Strength.03)	3.08	8.38	2003/c
	Recovery/Recycling of In-house Glass Manufacturing Waste (glassrecycle.03.new)	0.34	1.85	2005/c
	Subtotal	**4.49**	**12.79**	na
	Grand Total	**30.56**	**79.28**	na

Rev. 10/31/01 Note: Total and adding of subtotals may differ slightly due to round-off.

Total primary energy savings in 2010 are projected to be about 31 trillion Btu, approximately 50% higher than the GPRA submission for FY 2001 (21 trillion Btu). Year 2020 energy savings for the FY 2003 portfolio are projected at about 80 trillion Btu, which is consistent with the GPRA submission for FY 2002 (81 trillion Btu). For comparison, the year-2010 projected energy savings are 11% of MECS 1998 primary energy consumption in the glass industry (293 trillion Btu). Our year-2020 projected energy savings are 27% of MECS 1998 primary energy consumption in the glass industry.

Changes from the GPRA 2002 submission, which occur mostly in the near-term, are due to a change in the model which allows the units penetrating the market prior to 2005 to be counted. 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. Eight projects were analyzed for the GPRA 2001 study and their analyses were revised for GPRA 2002; nine additional glass R&D projects were included in the GPRA 2002 study. For the GRPA 2003 submission, 3 completed projects were removed and four new projects were added.

- Metal Casting Industry Vision

Table 10. Metal Casting Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	21	35	56	75	97	117
2. Energy Cost Savings (B$)	0.080	0.158	0.255	0.355	0.441	0.519
3. Carbon Reduction (MMTCE)	0.39	0.79	1.30	1.83	2.33	2.80

Projected benefits for the Metal Casting Industry Vision were based on analysis of 27 active R&D projects addressed to improvements in energy efficiency and environmental performance of metal casting processes. The table below identifies these projects, grouping them into separate targets. It is estimated that these projects represent approximately 95% of the FY 2003 R&D budget. The FY 2002 total budget for the Metal Casting Industry Vision is $5.357 million. 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 233 trillion Btu (Source: DOE/EIA 1998 MECS). 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 34.49 trillion Btu, approximately 95% greater than the GPRA submission for FY 2002 (17.7 trillion Btu). Year 2020 energy savings for the FY 2003 portfolio are projected at about 75.34 trillion Btu, 5.5% greater than the GPRA submission for FY 2002 (71.4 trillion Btu). For comparison, the year-2010 projected energy savings are 17% of 1994 primary energy consumption in the metal casting industry (200 trillion Btu); 15% of the 1998 energy consumption; and 13% of an informal OIT baseline projection for 2010 (264 trillion Btu).

Changes from the GPRA 2002 submission are most significant in the 2010 time frame. This is due to changes in the energy benefits model. Differences in 2020 between the GPRA 2002 and the GPRA 2003 submission are negligible. Also, in GPRA 2003 as in GPRA 2002, consideration was made for potential overlaps in the target market areas for the various technologies. To attempt to account for the overlap, revisions in projected market penetration were made which further reduced savings estimates for some individual projects from GPRA 2001 levels. Also, as in GPRA 2002 more conservative assumptions were made about the date of market introduction for the technologies. This often moved out the year of market introduction by one to two years. Revisions in our assumptions for market penetration and year of market introduction were due in part to review comments received during the an earlier analysis of metal casting benefits spreadsheets used in preparing the GPRA response. The table below indicates the year of market introduction assumed and the letter selector assigned to characterize the technology's market penetration in the spreadsheet model.

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	0.254	1.16	2003/c
	Computer modeling of the mechanical performance of die casting dies	3.04	6.11	2003/b
Die Life Extension/Die Performance	Surface Engineered Coatings for Die Casting Dies	0.0505	0.155	2003/c
	Integration of RSP Tooling in die casting	0.506	1.56	2003/c

Materials properties and performance (molds, dies, and castings)	Systematic microstructure corrosion performance of stainless steel	0.679	1.63	2002/c
	Mold Materials of Permanent Molding of Aluminum Alloys	0.791	1.84	2002/c
	Grain refinement of Permanent mold cast copper base alloys	0.735	1.44	2002/c
	Creep resistant zinc alloy development	0.321	0.662	2002/c
	Investment shell cracking	0.0951	0.253	2002/c
	Service performance of welded duplex stainless steel castings	0.0644	0.0813	2002/b
Thin Wall/High Strength castings	Thin wall cast iron	0.634	2.02	2003/c
	Clean, machinable thin walled gray and ductile iron casting	3.45	7.85	2002/c
Advanced casting methods	Lost Foam	3.45	5.86	2000/c
	Metallic Reinforcement of the squeeze casting process	0.367	0.968	2003/c
Machining; inclusions, porosity reduction	1. Clean Steel Machinability, and 2. Accelerate Transfer of Clean Steel	2.15	3.44	2000/c
	Prevention of porosity formation and other effects of gaseous elements	1.66	4.04	2003/c
	Improvements in sand/mold/cor technology: effect on casting finish	2.42	4.99	2002/c
Energy guidelines; Emissions Reduction; Byproduct Reuse	Energy consumption in die casting operations	2.99	5.06	2002/b
	Non-incineration treatment to reduce benzene emissions	4.40	10.00	2002/c
	Technical data to validate foundry byproducts in hot mix asphalt	0.0224	0.0242	2002/a
Sensors	Sensors for die casting	0.935	2.25	2002/c
Steel Foundry Practices (e.g. gating, heat treating, process re-engineering)	1. Re-engineering casting production systems and 2. Ergonomic improvements of casting production systems	0.273	0.511	2001/c
	Yield Improvement in Steel Castings	2.18	4.49	2002/c
	Heat Treatment procedure qualification for steel casting	0.436	0.881	2002/c
Die Casting Practices (e.g. gating, process control, die filling, etc)	Gating of aluminum permanent mold castings	1.17	3.91	2002/c
	Ultrahigh speed measurement of internal die cavity temperature for process control	0.866	2.67	2003/c
	Effect of externally solidified product on wave celerity	0.546	1.48	2002/c
	Grand Total	**34.49**	**75.34**	**na**

- Steel Industry Vision

Table 12. Steel Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	30	71	112	151	188	219
2. Energy Cost Savings (B$)	0.074	0.176	0.292	0.422	0.549	0.669
3. Carbon Reduction (MMTCE)	0.49	1.54	2.67	4.05	5.63	7.14

The GPRA submission for the Steel Vision is based on analysis of 24 technologies related to enhancing the productivity, energy efficiency, and environmental performance of steel manufacturing processes (see table below). The Steel Team's FY 2002 R&D budget is approximately $9.7 million. The projects listed below represent approximately 80% of the budget, compared to the 75% figure for the 21 projects analyzed for the GPRA 2002 submission. The total FY 2002 budget for the Steel Industry Vision is $10.329 million.

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	11.5	16.6	2003/b
	Hot Oxygen Injection into the Blast Furnace	3.1	4.8	2003/b
	Quantifying the Thermal Behavior of Slags	3.0	6.5	2003/c
	Automated Steel Cleanliness Tool	4.0	5.8	2003/b
	Magnetic Gate for Molten Metal Flow Control	1.0	1.6	2003/b
	QMST	0.4	1.0	2004/c
Combustion/Environment	NO x Emission Reduction by Oscillating Combustion	2.0	2.6	2003/b
	Dilute Oxygen Combustion	4.4	12.8	2003/c
	Nitrogen Control in EAF Steelmaking by DRI Fines Inject	3.4	11.0	2005/c

	Non-Cr Passivation	0.0	0.1	2004/c
	Optical Sensor for EAF Post-Combustion Control	1.6	3.1	2004/b
	Optimization of Post-Combustion in Steelmaking	3.0	6.7	2003/c
	PCI Coal Combustion Behavior	0.0	0.1	2004/c
	Sustainable Steelmaking Using Biomass and Waste Oxides	3.1	12.1	2007/c
Materials	Intermetallic Alloys For Steel	3.8	9.5	2003/c
	Improved Refractory Service Life and Recycling Refractory Materials	1.7	3.7	2003/c
	Development of Submerged Entry Nozzles that Resist Clogging	9.5	18.1	2003/b
Quality	Laser-Assisted Arc Welding	0.1	0.3	2003/c
	Controlled Thermo-Mechanical Processing of Tubes and Pipes	2.5	4.6	2003/b
	Development of Steel Foam Materials and Structures	1.1	3.6	2006/c
	Clean Steels – Advancing the State of the Art	5.9	18.5	2005/c
	Formability of HSS steels	1.5	2.2	2003/b
	Fatigue/Crash Performance HSS	1.5	2.2	2003/b
	Hydrogen and Nitrogen Control in the Ladle and Casting	2.7	3.5	2003/b
	Total	70.8	151.0	na

Total primary energy savings in 2010 are projected to be 70.8 trillion Btu, compared to 58.6 trillion Btu in GPRA 2002. Year-2020 primary energy savings for the FY 2003 portfolio are projected at about 151 trillion Btu, compared to 178 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 4% of the projected baseline energy use in the industry.

Five projects analyzed for GPRA 2002 were dropped from this analysis (Strip Casting, Nox Emissions from Byproduct Fuels, Oxy-fuel Burners, Removal of Residual Elements in the Ladle, and Nickel Aluminide Transfer Rolls) because they were completed. Eight other steel projects were added to the GPRA 2003 analysis. The primary energy savings results were slightly higher than in last year's analysis because some of the projects dropped had large energy savings and most of the new projects added offer relatively modest energy savings.

The project entitled “NOx Emission Reduction by Oscillating Combustion” is funded 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.

- Mining Industry Vision

Table 14. Mining Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	41	76	126	167	208	239
2. Energy Cost Savings (B$)	0.156	0.337	0.555	0.759	0.920	1.04
3. Carbon Reduction (MMTCE)	0.80	1.75	2.92	4.04	4.99	5.73

The Mining Industry of the Future program portfolio is currently funding 26 active R&D projects. Projected benefits for the Mining Industry Vision were based on analysis of 20 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 lists the projects evaluated, merging them where appropriate. These projects represent approximately 80% of the FY 2003 R&D budget. The total FY 2002 budget for the Mining Industry Vision is $5.119 million.

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 Sector
Materials	Cellular-03	2.74	7.83	2004/c
Sensors	Grader-03	0.142	0.381	2004/c
	Imaging-03	2.22	4.39	2001/c

	Geophone-03	**1.96**	**4.94**	**2003/c**
	Libs-03	**13.7**	**33.3**	**2003/c**
Alternative Fuels	**Fuelcell-03 PhaseII-03**	**1.59**	**4.55**	**2004/c**
Modeling	**Comminution-03**	**10.7**	**28.4**	**2004/c**
	Sag-03	**5.10**	**10.5**	**2002/c**
Communications	**Communications-03**	**1.11**	**2.30**	**2002/c**
Processing	**DMC-03**	**0.966**	**2.45**	**2003/c**
	Analyzers-03	**5.59**	**12.0**	**2004/b**
	Byprodrecov-03	**19.1**	**29.3**	**2003/b**
	Flocculation-03	**3.02**	**6.29**	**2002/c**
Excavation	**Cutting-03**	**0.215**	**0.619**	**2004/c**
	Bolter-03	**0.302**	**0.647**	**2004/b**
	Robotics-03	**2.19**	**6.39**	**2004/c**
	blasting-03	**4.76**	**11.2**	**2003/c**
	Projectile-03	**0.513**	**1.36**	**2004/c**
	oilpro-03	**0.113**	**0.156**	**2002/b**
Total		**76.1**	**167.4**	

Total primary energy savings in 2010 are projected to be about 76.1 trillion Btu. Year 2020 energy savings for the FY 2003 portfolio are projected at about 167.4 trillion Btu. For comparison, the year-2010 projected energy savings are 6.8% of 2001 primary energy consumption in the mining industry (1,125 trillion Btu) and 6.2% of an informal OIT baseline projection for 2010 (1,230 trillion Btu). Our year-2020 projected energy savings are 14.9% of 2001 primary energy consumption in the mining industry and 13.6% 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 2003 projected energy savings in 2010 are 172% higher than the 2002 GPRA submission (27.94 trillion Btu). Changes from the GPRA 2002 submissions are due to the addition of 2 reviewed projects in the portfolio. Assumptions made in 2002 were updated with more current data. Also, market penetration rates were updated with more current data. The percent of the 2003 budget captured in GPRA increased from 75% in GPRA 2002 to 80% in GPRA 2003. 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.

1. Agriculture Industry Vision

Table 16. Agriculture Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	61	189	355	545	801	1,208

2. Energy Cost Savings (B$)	0.345	0.997	1.873	2.845	4.328	6.652
3. Carbon Reduction (MMTCE)	0.24	1.07	2.58	4.71	8.27	14.5

Projected benefits for the Agriculture Industry Vision were based on analysis of 11 active R&D projects addressing the development of new biobased chemicals and materials as well as improvements in the conversion of agricultural products and residues to high-value chemical building blocks and other industrial products. Social advantages of these technologies include the substitution of renewable resources for petrochemical feedstock and the development of substitutes for key commodities that are biodegradable, environmentally-benign, or are manufactured using environmentally-friendly processes. The table below identifies these projects, grouping them into separate targets including high purity lactate esters from rice straw, propylene glycol from wheat milling residue and corn, biodegradable thermoplastic products from corn, biodegradable 2-cycle engine lube oils from soybean oil, a new separation/purification technology for biomass conversion to products, vegetable oil-based polymers, polytrimethylene terephthalate polymer precursor, and a strength-enhancing polymer additive. It is estimated that these projects represent approximately 28% of the $7.259 million FY 2002 R&D budget. The remaining FY 2002 R&D budget is targeted for 6 recently awarded projects.

Table 17. Summary of Project Runs – Agriculture Industry Vision

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro/Market Selector
High purity lactate esters (for non-toxic solvents) from rice straw	Advanced Biocatalytic Processing of Heterogeneous Lignocellulosic Wastes (EthylLactate Dec31)	2.45	22.3	2007/ b
Propylene glycol, other polyols from wheat milling residue and corn	Value Added Products From Wheat Milling By-Products (Wheat Dec31)	1.20	14.9	2008/ b
	Catalytic Upgrading of Glucose to Value-added Products (G2P Dec31)	2.47	19.1	2007/ a
Improved process for making high fructose corn syrup	Commodity Scale Thermostable Enzymatic Transformations (HFCS Dec31)	7.2	18.7	2004/ b
Biodegradable, benign domestic thermoplastic packaging, diapers	Enhanced Utilization of Corn-Based Polymer Materials (CargillDow Dec31)	120	210	2002/ b
Biodegradable 2-cycle water cooled engine lube	Soy-based 2-cycle Engine Oils For Water-Cooled Engines (SoyEngineOil Dec31)	0.4	0.7	2003/ b
Novel process to cleanly separate wood fiber (and other lignocellulosics)	Clean Fractionation: An Inexpensive Source of Cellulose for the Production of Cellulose Plastics (CF Dec31)	2.28	6.50	2006/ a

into cellulose, hemicellulose, and lignin for plastics and other value-added products	of Cellulose Plastics (CF Dec31)			
New purification and separation technology for biomass conversion to chemicals	Industrial Membrane Filtration and Short-Bed Fractal Separation Systems for Separating Monomers from Heterogeneous Plant Material (membr sep Dec31)	10.5	105	2006/ c
Vegetable oil-based polymers for use in coatings, foams, and plastics	Functionalized Vegetable Oils for Utilization as Polymers Building Blocks (FuncVegOils Dec31)	10.4	32.1	2004/ b
Thermoplastic polymer (polytrimethylene terephthalate–PTT) with enhanced properties	1,3-Propanediol Via Fermentation-Derived Malonic Acid (propanediol Dec31)	1.6	10.4	2005/ b
Strength-increasing polymer additive (for use in PET plastics)	Continuous Isosorbide Production Using Solid Acid Catalysts (isosorbide Dec31)	30.2	105	2005/ b
	Total	188.7	544.7	n/a

Total primary energy savings in 2010 are projected to be about 188.7 trillion Btu, approximately twelve times the GPRA submission for FY 2002 (15.4 trillion Btu). Year 2020 energy savings for the FY 2003 portfolio are projected at about 544.7 trillion Btu, more than five times the GPRA submission for FY 2002 (100 trillion Btu).

The treatment of biomass feedstock energy in GPRA analysis has changed, boosting the primary energy savings for many of the projects. Since biomass feedstocks replace fossil energy inputs, the energy content of biomass feedstock is not subtracted from the primary energy savings total as it was in the past, although the cost and any emissions associated with the use of biomass are included in the energy cost savings and carbon reduction totals. The addition of five new projects also helped to increase projected energy savings and carbon reduction.

1. Petroleum Refining Industry Vision

Table 18. Petroleum Refining Industry Vision - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	17	36	71	122	180	234
2. Energy Cost Savings (B$)	0.056	0.125	0.259	0.468	0.712	0.952
3. Carbon Reduction (MMTCE)	0.31	0.69	1.39	2.42	3.57	4.63

Projected benefits for the Petroleum Refining Industry Vision were based on analysis of the 6 active R&D 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 ethylene production process control, improving combustion efficiency, and substituting membrane separation for distillation. It is estimated that these projects represent approximately 86% of the $2.80 million FY 2002 budget.

Table 19. 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	19.5	65.6	2005/c
Pressure Vessel Integrity	Assuring Mechanical Integrity of Refinery Equipment Through Global On-Stream Inspection	1.5	5.1	2005/c
Facility Emission Control	Hydrocarbon Leak Detector	1.5	5.4	2005/c
Ethylene Production From Gas Oil	Micro-GC Controller for Petrochemical Application	1.4	4.7	2004/c
Combustion Efficiency	Rotary Burner Demonstration	5.6	17.6	2004/c
Distillation Energy Use	Energy Saving Separation Technologies for the Petroleum Industry	6.7	23.8	2005/c
	Total	36.1	139.2	na

Total primary energy savings in 2010 are projected to be about 36.1 trillion Btu, approximately 30% of the GPRA submission for FY 2002 (120 trillion Btu). Year 2020 energy savings for the FY 2002 portfolio are projected at about 139 trillion Btu, about 29% of the GPRA submission for FY 2002 (466 trillion Btu). For comparison, 1994 energy consumption by the petroleum refining industry was approximately 3.413 quads for combustion and power plus 3.168 quads in the form of fuels used as feedstocks. The largest energy-consuming processes in petroleum refining are atmospheric and vacuum distillation, hydrotreating, reforming, fluid catalytic cracking and catalytic hydrocracking.

Reductions in primary energy savings from the GPRA 2002 submission are due to the deletion of 5 projects and the addition of 1 new project, as well as the use of more conservative assumptions.

1. Industrial Materials Crosscut

Table 20. Industrial Materials for the Future Program - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	31	74	133	207	284	362
2. Energy Cost Savings (B$)	0.055	0.162	0.297	0.511	0.763	1.070
3. Carbon Reduction (MMTCE)	0.31	0.86	1.58	2.62	3.89	5.50

The GPRA submission for Industrial Materials is based on a spreadsheet benefits analysis of technical innovations under development by 12 projects, which are listed in the table below. Most of the technologies under development have applications in multiple industries. Benefit estimates were generally based upon single application of a technology. Additional potential applications are generally not included in the analysis. The 12 projects represent about 75% of IMF's $5.5 million FY2002 R&D budget. The total FY 2002 budget for the Industrial Materials for the Future planning element is $6.698 million.

Table 21. 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
Power - IGCC	High-Temperature Facilitated Transport Membranes	0.0	2.8	2012/d
Ethylene and propylene	Membrane Systems for Energy-Efficient Separation of Light Gases	3.8	9.6	2008/d
Chemicals - ethylene cracking	Improved Materials for Ethylene Cracking	26.0	81.8	2004/c
Glass melting	Synthesis and Design of Silicide Intermetallic Materials	0.1	11.2	2010/a
Glass production - oxyfuel furnaces	Refractories	9.1	15.1	2003/b
Kraft recovery boiler	Boiler Materials	9.4	24.3	2004/c
Process heating	Coatings	7.5	15.4	2005/d
Forest - Black liquor and biomass gasifiers	Development of Materials for Gasifiers	2.9	11.0	2010/c
Aluminum and titanium forging	IR AL Billets Forging	0.3	0.6	2004/b
Aluminum and steel die heating	IR Die Heating	0.5	1.1	2004/b
Steel casting; heat treating of steel	Intermetallic Alloy Development for the Steel Industry	2.3	7.4	2005/c

slabs				
Steel - heat treating	**Intermetallic Alloy Development for Heat Treat Carburization**	**12.7**	**27.0**	**2004/b**
	Total	**74.4**	**207.2**	**na**

Total primary energy savings in 2010 are projected to be 74 trillion Btu, over three times the GPRA submission for FY 2002 (22 trillion Btu). Year-2020 primary energy savings for the FY 2003 portfolio are projected to be about 207 trillion Btu, more than twice the 86 trillion Btu result of the GPRA 2002 analysis.

Eleven of the projects are new for FY2003: High-Temperature Facilitated Transport Membranes; Membrane Systems for Energy-Efficient Separation of Light Gases; Improved Materials for Ethylene Cracking; Synthesis and Design of Silicide Intermetallic Materials; Refractories; Coatings; Development of Materials for Gasifiers; IR AL Billets Forging; IR Die Heating; Intermetallic Alloy Development for the Steel Industry; and Intermetallic Alloy Development for Heat Treat Carburization.

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. The savings are larger than in GPRA 2002 due to the large potential impact of the new projects added this year. A major analysis of the IMF GPRA was completed by the National Renewable Energy Laboratory in early 2002 [J. Mortensen, "Industrial Materials for the Future (IMF) FY2003 GPRA Benefits & Performance Measurement Analysis." National Renewable Energy Laboratory, Golden Colorado, 2002].

1. Sensors and Controls Crosscut

Table 22. Sensors and Controls Program - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	1	9	27	37	42	47
2. Energy Cost Savings (B$)	0.004	0.029	0.087	0.120	0.140	0.161
3. Carbon Reduction (MMTCE)	0.03	0.22	0.64	0.85	0.95	1.05

Projected benefits for the Sensors & Controls (S&C) Program Vision are based on analysis of 10 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 90% of the $3.774 million FY 2002 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 23. 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 Instruments	Thermal Imaging Control of Furnaces and Combustors	1.29	3.94	2004/b
	Remote Material On-line Sensor	0.67	3.48	2005/b
	In-Situ, real-Time Measurement of Melt Constituents	0.83	3.02	2005/b
	Tunable Diode Laser for Harsh Combustion Environments	0.21	2.44	2006/b
	On-line Measurement Using Laser-Based Ultrasonic System	0.29	1.46	2006/b
	Solid State Chemical Sensors for Monitoring Hydrogen	1.07	3.64	2005/b
Control and Optimization	Cupola Furnace Control System	1.58	5.04	2005/b
	Sensor Fusion for Intelligent Process Control	0.41	1.49	2005/b
	Intelligent Extruder	0.39	1.04	2004/b
	Diagnosis and Control of Natural Gas Fired Furnaces via Flame Image Analysis	2.45	11.20	2006/b
	Total	9.19	36.75	na

Total primary energy savings in 2010 are projected to be about 9.19 trillion Btu, 55% greater than the GPRA submission for FY 2002 (5.88 trillion Btu). Year 2020 energy savings for the FY 2003 portfolio are projected at about 36.75 trillion Btu, 60% greater than the GPRA

submission for FY 2002 (22.9 trillion Btu).

Four of the ten project analyses were revised for GPRA 2003. These were the Remote Material On-line Sensor, In-Situ, Real-time Measurement of Melt Constituents, Solid State Chemical Sensors for Monitoring Hydrogen, and Diagnosis and Control of Natural Gas Fired Furnaces via Flame Image Analysis. All of these projects were revised with updated assumptions that resulted in higher energy savings and other projected benefits. The revisions reflect the progress of individual projects toward market readiness as well as the use of an expanded market size across U.S. industry and an aggressive market penetration rate. 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.

2. Combustion Crosscut

Table 24. Combustion Program - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	16	34	65	106	147	183
2. Energy Cost Savings (B$)	0.051	0.114	0.225	0.396	0.583	0.769
3. Carbon Reduction (MMTCE)	0.24	0.52	0.98	1.60	2.22	2.76

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 NO_x, Low Swirl Burner. The Combustion Program's FY 2002 budget is approximately $18.391 million, with the projects listed below representing approximately 60% of the budget.

Table 25. 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	13.1	39.3	2004/c
Advanced, Integrated Process Heater/Burner System	21.1	66.5	2004/c
Low NO_x, Low Swirl Burner	0.04	0.08	2004/b
Total:	**34.2**	**105.9**	n/a

Total primary (counting electricity generation and transmission losses) energy savings in 2010 are projected to be 34.2 trillion Btu, compared to 20.9 trillion Btu in GPRA 2002. Year-2020 primary energy savings for the FY 2003 portfolio are projected at about 105.8 trillion Btu, compared to 103.4 trillion Btu last/year.

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 2004 with market penetration curve "c". The much larger Integrated Process Heater/Burner System is for both retrofits and new advanced installation in the chemicals and petroleum industries. Market introduction in 2004 is assumed with a penetration curve "c" in the spreadsheet model.

The Low NO_x, 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 "b".

1. *Technical and Financial Assistance Planning Units*

The Inventions and Innovation program and NICE[3] program were assessed using the same prospective benefits projection methodology as was applied to all R&D planning units. This was the first GPRA analysis in which the I&I program was assessed in this way; previously a retrospective analytical approach was used.

The Industrial Analysis Center program and the BestPractices program were again assessed based on retrospective analysis of performance data accumulated over a period of years. Quality Metrics for these Technical and Financial Assistance 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.

Inventions and Innovation (I&I) Program

Table 26. I&I Program - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	61	112	194	283	365	424
2. Energy Cost Savings (B$)	0.196	0.396	0.695	1.052	1.391	1.659
3. Carbon Reduction (MMTCE)	1.00	1.98	3.44	5.13	6.61	7.69

The Inventions and Innovation (I&I) program provides financial assistance at two levels: up to $40,000 (Category 1) or up to $200,000 (Category 2). The GPRA submission for the I&I Program is based on the analysis of 21 Category 2 energy-related technologies projects (see table below). The I&I Program FY2002 budget is approximately $4.372 million. The projects listed below represent approximately 70% of the budget.

Table 27. Summary of Project Runs – Inventions and Innovation Program

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Agriculture	Energy-Saving Grain Drying Invention	30.2	88.4	2005/c
	Seed Screening Using Near-Infrared Spectroscopy [1]	-	-	-
Chemicals	Compact and Efficient Chemical Reactor [i]	-	-	-
Forest Products	Deposition Detection and Control in Kraft Recovery Boilers	3.09	7.05	2003/c
	Efficient and Environmentally Benign Papermaking Technology	2.6	6.28	2003/c
	Integrated Acoustic Kiln Monitor for Wood Drying	1.09	2.49	2003/c
Glass	High-Throughput Vacuum Processing for Innovative Uses of Glass	0.0003	0.002	2003/c
	Thermophotovoltaic Electric Power Generation Using Exhaust Heat	1.11	3.03	2004/c
Metal Casting	Casting-Quality Measurements for Polystyrene Foam Patterns	0.16	0.51	2005/c
	Computer Process Model for the Cupola Furnace	5.59	12.7	2003/c
	High-Frequency Eddy-Current Separator for Foundry Sands	4.0	7.67	2002/c
	Hot Eye-Based Coordinate Measuring Machine	0.75	1.58	2003/c
Mining	Dynamic Cyclone Classifier for Soft Ceramic Particles	10.6	30.3	2003/c
	Lower pH Copper Flotation Reagent System	1.09	1.37	2003/c
Petroleum	Dual-Function Absorption Cycle Using Low-Level Refinery Heat	22.2	47.1	2003/c
Other Industries	Advanced Overfire Air System for Stoker Boilers/Furnaces	1.03	2.34	2003/c
	Industrial Fuel Cell Microgenerator	2.44	6.63	2003/c
	Miniature, Inexpensive Amperometric Zirconia Sensor	19.6	50.8	2003/c
	Process Particle Counter for Power-Recovery Expanders and	6.36	14.5	2003/c

	Gas Turbines			
	Total	112.0	282.9	

Total primary (counting electricity generation and transmission losses) energy savings in 2010 are projected to be 112 trillion Btu, compared to 21 trillion Btu in GPRA 2002. Year 2020 primary energy savings for the FY2003 portfolio are projected at about 283 trillion Btu, compared to 108 trillion Btu last year. The Category 1 technology projects were not included in this analysis as they are conceptual in nature and it is too early to estimate the energy impact they would have in the United States. The I&I program was evaluated in GPRA 2003 for the first time using the same OIT Impact Projections Model as was used for all R&D planning elements and the NICE^3 planning element. Previously, the I&I program was evaluated using a retrospective analysis similar to the approach currently used for the IAC and Best Practices planning elements.

The 19 Category 2 technology projects shown in the table include two that are enabling technologies. Enabling technologies do not by themselves save primary energy but when used with other technologies will do so in the future. The first enabling technology, Compact and Efficient Chemical Reactor, would be used as part of an advanced fuel cell, and the other enabling technology, Seed Screening Using Near-Infrared Spectroscopy, would help increase crop yields by identifying the best seeds to plant. The other 17 Category 2 technologies were analyzed by interviewing each of the industry partners and working with them to identify an energy savings methodology for their technology as well as the year the technology would be available commercially.

NICE^3 Program

Table 28. NICE^3 Program - QM Rollup

Item	2005	2010	2015	2020	2025	2030
1. Primary Energy Savings (TBtu)	21	45	79	121	165	204
2. Energy Cost Savings (B$)	0.075	0.167	0.313	0.513	0.724	0.928
3. Carbon Reduction (MMTCE)	0.36	0.83	1.53	2.41	3.30	4.12

The U.S. Department of Energy's (DOE) Office of Industrial Technologies (OIT) sponsors the National Industrial Competitiveness through Energy, Environment, and Economics (NICE^3) grant program as an innovative, cost-sharing initiative to: (1) encourage cleaner production and manufacturing processes in the United States, (2) reduce wastes in industry, (3) conserve energy and energy-intensive materials, and (4) improve industrial cost-competitiveness. The NICE^3 program was authorized to improve the energy efficiency and cost-effectiveness of pollution prevention technologies and processes, including source reduction and waste minimization technologies and processes. NICE^3 was initiated in 1991.

The grant program provides funding to state and industry partnerships (large and small business) for projects that develop and demonstrate advances in energy efficiency and clean production technologies. Industry applicants must submit project proposals through a state energy, pollution prevention, or business development office. State and Industry partnerships are eligible to receive a one-time grant of up to $525,000. The industrial partner may receive a maximum of $500,000 in federal funding. Non-federal cost share must be at least 50% of the total cost of the project.

The GPRA submission for the NICE^3 Program is based on the analysis of the 11 technologies shown in the table below. These technologies represent 100% of the $2.736 million FY 2002 budget for NICE^3.

Table 29. Summary of Project Runs – NICE^3 Program

Impact Target	Project	Energy Savings (TBtu) 2010	Energy Savings (TBtu) 2020	Year of Intro / Market Selector
Agriculture	**Flex Microturbine for Pecan Waste**	**2.52**	**6.67**	**2004/c**
Aluminum	**Non-Vacuum Electron Beam Welding**	**0.54**	**1.39**	**2003/c**
Chemicals	**Inspection Method for On-Stream Process Piping at Support Areas**	**1.05**	**3.60**	**2005/c**
Forest Products	**Adjustable Speed Drives for 500+ Hp Applications**	**15.60**	**38.70**	**2002/c**
	Particle Size Reduction for Wastewater Treatment	**0.14**	**0.30**	**2003/c**
	Pressurized Ozone Membrane Ultrafiltration for TDS Removal	**8.22**	**19.50**	**2003/c**
Metal Casting	**Improved Lost Foam Casting Process**	**10.50**	**33.00**	**2004/c**
	Improved Magnesium Molding Process	**0.26**	**0.86**	**2004/b**
Steel	**Vanadium Carbide Coating Process**	**2.60**	**7.89**	**2006/c**
Other Industries	**Dual Pressure Euler Steam Turbine**	**2.96**	**9.36**	**2004/c**
	Foam Dyeing	**0.12**	**0.24**	**2002/c**
	Total	**44.53**	**121.45**	

Total primary (counting electricity generation and transmission losses) energy savings in 2010 are projected to be 44.53 trillion Btu, compared to 9.13 trillion Btu in GPRA 2002. Year 2020 primary energy savings for the FY2003 portfolio are projected at about 121.45 trillion Btu, compared to 43.55 trillion Btu last year. The increase in projected savings is due to the addition of two projects and revised market assumptions for several others. The 11 technologies were analyzed by interviewing each of the industry partners and working with them to identify an energy savings methodology for their technology as well as the year the technology would be available commercially.

Industrial Assessment Center (IAC) Program

Table 30. IAC Program - QM Estimation and Summary

Item	2003	2004	2005	2006	2010	2015	2020	2025	2030
1. Number of Audits	750	750	750	750	750	750	750	750	750
2. Cumulative Number of Audits 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/Audit-Year)	3686	3686	3686	3686	3686	3686	3686	3686	3686
4. Energy Saved From Audits (TBtu)	2.76	5.53	8.29	11.06	19.35	19.35	19.35	19.35	19.35
5. IAC Audit 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	1350	1,575	1,575	1,575	1,575
7. Annual Energy Saved From Replications (TBtu)	0	0	0.83	1.66	4.98	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 Audits 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 Audits Performed	70	140	210	280	560	910	1,050	1,050	1050
11. Cumulative Number of Alumni Energy Audits	70	210	420	700	2520	6370	11550	16800	22050
12. Number of Aged Energy Audits Retired	0	0	0	0	70	420	770	1050	1050
13. Cumulative Number of Aged Energy Audits Retired	0	0	0	0	70	1470	4620	9450	14700
14. Number of Alumni Energy Audits Counted	70	210	420	700	2450	4900	6930	7,350	7350

15. Annual Energy Saved From Alumni Audits (TBtu)	0.26	0.77	1.55	2.58	9.03	18.06	25.54	27.09	27.09
16. Additional Annual Energy Saved Per Website (TBtu/Year)	1	1	1	1	0	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	40.36	50.22	57.7	59.25	59.25
19. Energy Cost Savings (B$)	0.019	0.038	0.062	0.089	0.195	0.261	0.323	0.341	0.351
20. Carbon Reduction (MMTCE)	0.068	0.142	0.241	0.348	0.758	0.923	1.044	1.072	1.072

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

Based on historical data on 9,775 industrial site assessments, the IAC program was assumed to result in the performance of 750 audits 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 2009, the resulting national energy savings attributed to this source levels off at 19.35 trillion Btu per year, because new audits afterward merely replace the contributions of aged audits no longer being counted (line 4).

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

Estimation of the contribution of audits (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 audit (actually, 2 audits, 25% of which are energy audits) each year for 15 years after leaving the IAC program and that each audit subsequently saves 3,686 million Btu per year. The benefits of each energy audit (or equivalent intervention) were assumed to persist for seven years, after which the aged energy audit was "retired" for the purposes of this estimation. Subtracting the cumulative number of aged energy audits "retired" (line 13) from the cumulative number of audits performed (line 11) gives the number of alumni audits 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 audit 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 2003, so that the level of savings in 2009 was continued without further increase. This contribution was considered a placeholder (33% of the website impact number in the report) pending the development of further website communication benchmark data. The FY 2002 budget is $6.859 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 2002 Data Call guidance.

Best Practices Program

OIT's Best Practices program is designed to change the ways industrial plant managers make decisions affecting energy use by motors and drives, compressed air, steam, combustion systems and other plant utilities. The FY 2001 budget is $10.35 million. An overall program methodology is currently under development with the help of Oak Ridge National Laboratory. Elements and very preliminary metrics are shown in Table 31. 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. Selected best-of-class large demonstration plants are showcased across the country, while other program activities encourage the replication of these best practices in still larger numbers of large size plants. Benefit contributions were computed for both the large plants participating directly in the program and the similarly large-size plants replicating the best practices demonstrated in the original plants.

Benefits for the large showcase plants were calculated based on a three-year history of "Plantwide Assessments" conducted. Of 21 such Plantwide Assessments conducted, 10 have completed recommendation reports. Based on these reports, potential energy savings are close to 2 trillion Btus per year per plant. Because this number may be skewed in favor of some extremely large pulp and paper plants, this number was reduced by half to project potential energy savings by the average Plantwide Assessment in the future. 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 actually 1/4 the magnitude of energy savings recommended in the 10 completed reports, or 0.482 trillion Btus per plant per year (line 3).

Table 31. Best Practices Program - QM Estimation and Summary

Item	2003	2004	2005	2006	2010	2015	2020	2025	2030
1. Plantwide Assessments (PWAs)	7	7	7	7	7	7	7	7	7
2. Cumulative Number of PWA Implementations	0	7	14	21	49	84	119	154	189
3. Annual Energy Saved Per Plantwide Implementation (TBtu/Plant-Year)	0	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482
4. Annual Energy Saved By Large Plant Implementation (TBtu)	0	3.37	6.74	10.12	23.62	40.49	57.36	74.23	91.10
5. Plantwide Replications	0	0	0	21	21	21	21	21	21
6. Cumulative Number of Large Plant Replications	0	0	0	21	105	210	315	420	525
7. Annual Energy Saved Per Large Plant Replication (TBtu/Plant-Year)	0	0	0	0.482	0.482	0.482	0.482	0.482	0.482
8. Annual Energy Saved By Replications (TBtu)	0	0	0	10.12	50.61	101.22	151.83	202.44	253.05
9. Collaborative Technology Assessments (CTAs)	27	27	27	27	27	27	27	27	27
10. Cumulative CTAs	27	54	81	108	216	351	486	621	756
11. Annual Energy Saved per CTA (TBtu/Plant-Year)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
12. Annual Energy Saved By CTAs (TBtu)	1.08	2.11	3.16	4.21	8.42	13.69	18.95	24.22	29.48
13. Plants Reached Through Training	1045	1045	1045	1045	1045	1045	1045	1045	1045
14. Cumulative Plants Reached Through Training	1045	2090	3135	4180	9405	14630	19855	25080	30305
15. Percent Taking Action	12.5	12.5	15.0	18.8	19.5	21.4	22.4	22.9	23.3
16. Average Energy Saved Per Plant Taking Action (TBtu/Plant-Year)	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265	0.0265
17. Annual Energy Saved By Training (TBtus)	3.5	6.9	12.5	20.8	48.5	83.1	117.8	152.4	187.1
18. Software Tools Distributed	9000	9000	9000	9000	9000	9000	9000	9000	9000
19. Unique Plants Reached	3000	3000	3000	3000	3000	3000	3000	3000	3000
20. Cumulative Unique ... d	3000	6000	9000	12000	27000	42000	57000	72000	87000

Plants Reached									
21. Percent Taking Action	5.0	5.0	5.0	5.0	6.0	7.0	7.5	7.8	8.0
22. Average Energy Saved Per Plant Taking Action (TBtu/Plant-Year)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
23. Annual Energy Saved By Software Tools Distribution (TBtus)	3	6	9	12	32.4	58.8	85.5	112.32	139.2
24. Plants reached by Publications	12600	13000	13500	17000	22200	24600	25600	26500	26800
25. Unique Plants reached by Publications	6300	6500	6750	8500	11100	12300	12800	13250	13400
26. Percent Taking Action	5	5	5	5	5	5	5	5	5
27. Average Energy Saved Per Plant Taking Action (TBtu/Plant-Year)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
28. Annual Energy Saved By Publication Distribution (TBtus)	3.15	3.25	3.375	4.25	5.55	6.15	6.4	6.625	6.7
29. Total Annual Energy Saved By Best Practices (TBtu)	10.7	21.4	34.7	61.5	169.1	303.4	437.8	572.2	706.6
30. Energy Cost Savings (B$)	0.031	0.062	0.099	0.179	0.511	0.987	1.533	2.057	2.609
31. Carbon Reduction (MMTCE)	0.15	0.30	0.49	0.90	2.55	4.49	6.39	8.35	10.31

The number of such large plants affected by the program was projected by the Best Practices program staff based on assumed level funding for five years (line 1). The annual energy saved directly by large plant program implementations (line 4) was calculated by multiplying the annual energy saved by each plant after entering the program (line 3) times the cumulative number of plants having entered the program (line 2). The effect was assumed to be permanent because the program is designed to change attitudes and management approaches on a permanent basis.

The benefits of plant replications was calculated by estimating that each industry leading large showcase plant entering the program would influence three 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 3. Program staff are in the process of documenting actual replication rates for each Plantwide Assessment recipient.

The number of new replication effects in year 2010 was assumed to continue through 2030 as additional plants replicate the best practices of industry leaders' plants (line 5). Annual energy savings from this source (line 8) were calculated by multiplying the cumulative number of large-size plant replications (line 6) by the annual energy savings rate (line 7).

Four new areas were added to this year's projection of future BestPractice Program benefits to reflect growth and maturation of significant program offerings. These areas include: Collaborative Targeted Assessments (CTAs), Training, Software Tool distribution, and Publication dissemination.

Collaborative Targeted Assessments (CTAs)

BestPractices has developed a new assessment initiative called CTAs 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 12) is calculated by multiplying the cumulative number of CTAs (line 10) times the median effect of all CTA's performed to date (line 11). Note that this effect, 0.04 TBtus per plant per year, is about 8% of the effect of a PWA. Energy savings from a typical CTA (0.04 TBtus) was derived from results reported in a spreadsheet entitled, "Activity Report for FY 2001" written by Oak Ridge National Laboratory. The FY 2002 Team Plan reports that over 40 CTAs were done in support of showcases, and over 10 for corporate training events. The energy savings numbers will continue to be refined as the program documents actual savings.

BestPractices plans to conduct 45 CTAs per year, but since 18 of these will be conducted in conjunction with WAS, it is assumed that their effect contributes to the overall effect of the WAS. Therefore, only 27 CTAs are culled out and counted separately (line 9). It is assumed that with level program funding, that BestPractices will continue to perform 27 CTA's per year through 2030.

Training

Training activities continue to play an increasingly important role in BestPractices program offerings. The Training activities reported in the "Activity Report for FY 2002" were used as a proxy for projections of future benefits. Results for Pump and Air training were taken from studies done by Xenergy, while Steam training results were inferred from 18 special Steam Assessments conducted in conjunction with six Industrial Assessment

Centers (IACs). The following table summarizes energy savings assumptions for training activities.

System	Training Sessions Per Year	Companies Per Session	Energy Savings / Company (TBtus)
Pumps	12	20	0.00145
Steam	7	25	0.0666
Air	21	30	0.0250

Multiplying sessions per year times companies per session from the table above, note that a total of 1,045 plants are reached through training events each year. This number is assumed to remain level with level program funding through 2030 (line 13). This is a conservative estimate since some companies will have multiple plant sites. Also, the "Train the Trainer" approach could lead to a geometric progression of the number of plants reached. Nonetheless, the 1,045 number is used and cumulated (line 14). This cumulative number is multiplied by the average energy savings per plant (line 16) and an estimate of the percent taking action (line 15) to calculate total annual energy savings from training (line 17). The percent taking action increases over time from 12.5% to close to 25% as awareness and motivation to take action increases over time.

Note that the average energy savings per plant of 0.0265 TBtus, derived by taking the weighted average of the trainings listed in the chart above, is a conservative estimate that does not include Process Heating energy savings training, which should substantially raise the average effect of training once such training is offered and more is known about its effect.

Although corporate and regional training events offer direct training to end-users, it is believed that the program will achieve a higher rate of marketplace penetration of BestPractices concepts through its "Train the Trainer" initiative. ORNL has been commissioned to conduct a more rigorous analysis of both the direct end-user and the "Train the Trainer" approach.

Software Tools Distribution

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.

Software Tools are distributed on CD-ROM or can be downloaded from the Internet. At this point in time we do not know how many plant level implementations and how much energy has been saved resulting from the use of these tools. 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 0.02 TBtus per plant-year (line 22), or half the value of a CTA (line 11), and 75% of the value of direct training (line 16). The number of plants affected by the software distribution is estimated by taking the total number of pieces of software distributed (line 18), dividing that number by 3 to account for multiple copies going to different people at the same plant site (line 19), and cumulating the total number of plants affected (line 20). This number (line 20) is then multiplied times the percent taking action (line 2; the percent taking action is assumed to start at a conservative 5% and increases to 8% by 2030, or about 1/3 the rate of those receiving training) times the average energy saved per plant per year (line 22) to determine the Annual Energy Saved from Software Distribution (line 23).

<u>Publication Dissemination</u>

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 12,600 in 2003 and increases to 26,800 by 2030 (line 24). This number is halved to estimate the total number of plants reached (line 25) and multiplied by 5% (line 26) to estimate the total number of plants where information from the publications is applied. "Average Energy Saved per Plant Taking Action (TBtus / Plant-Year)" is shown in (line 27). This estimate of 0.01 TBtus is half the estimate used for software tool distribution and 38% of the number used to estimate the effect of Training. Annual Energy saved by the application of information in publications (line 28) is the product of Unique Plants Reached by Publications (line 25), times the Percent Taking Action (line 26), times the Average Energy Saved per Plant Taking Action (line 27).

Appendix A - 2003 Quality Metrics Final Summary Tables

GPRA 2003 PROJECTED PROGRAM BENEFITS - OFFICE OF INDUSTRIAL TECHNOLOGIES

ng Element	YEAR 2010			YEAR 2020			YEAR 2030		
	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 1998 $)	Carbon Reduction (MMTCE)	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 1998 $)	Carbon Reduction (MMTCE)	Primary Energy Savings (TBtu)	Energy Cost Savings (Billion 1998 $)	Carbon Reduction (MMTCE)
um	76	0.28	2.0	194	0.80	6.1	365	1.62	10.9
als	233	0.73	4.0	786	2.68	13.9	1,652	6.37	29.9
Products	187	0.90	4.4	971	4.87	24.1	2,397	11.41	59.9
	31	0.11	0.6	79	0.31	1.5	130	0.54	2.5
Casting	35	0.16	0.8	75	0.36	1.8	117	0.52	2.8
	71	0.18	1.5	151	0.42	4.1	219	0.67	7.1
	76	0.34	1.7	167	0.76	4.0	239	1.04	5.7
ture[1]	189	1.00	1.1	545	2.84	4.7	1,208	6.65	14.5
um Refining	36	0.13	0.7	122	0.47	2.4	234	0.95	4.6
ecific S/T	*934*	*3.83*	*16.8*	*3090*	*13.51*	*62.6*	*6561*	*29.77*	*137.9*
aterials	74	0.16	0.9	207	0.50	2.6	362	1.07	5.5
& Controls	9	0.03	0.2	37	0.12	0.9	47	0.16	1.1
stion	34	0.11	0.5	106	0.40	1.6	183	0.77	2.8
D Subtotal	*117*	*0.3*	*1.6*	*350*	*1.02*	*5.1*	*592*	*2*	*9.4*
	40	0.19	0.8	58	0.32	1.0	59	0.35	1.1
nnov.	112	0.40	2.0	283	1.05	5.1	424	1.66	7.7
	45	0.17	0.8	121	0.51	2.4	204	0.93	4.1
actices	169	0.51	2.6	438	1.53	6.4	707	2.61	10.3
otal	*366*	*1.27*	*6.2*	*900*	*3.41*	*14.9*	*1394*	*5.55*	*23.2*
sscut S/T	*483*	*1.57*	*7.8*	*1250*	*4.43*	*20*	*1986*	*7.55*	*32.6*
	1417	**5.4**	**24.6**	**4340**	**17.94**	**82.6**	**8547**	**37.32**	**170.5**

[1] Benefits of the Agriculture IOF program include large substitutions of biomass feedstock for fossil fuel feedstock currently used in the production of chemicals. The quantity of fossil fuel feedstock displaced annually by such fuel substitutions is projected to be approximately 55-60% of the total primary energy saved by the program, with the remainder being made up by process efficiency improvements. The energy content of biomass feedstock consumed is not included in the primary energy savings total, but the costs and air emissions associated with the use of biomass as feedstock are included.

12-31-01

GPRA 2003 QUALITY METRIC (QM) TRENDS

g Element	2010 Energy Savings (TBtu)			2020 Energy Savings (TBtu)			% of Budget Represented[1]		
	2001 QM	**2002 QM**	**2003 QM**	**2001 QM**	**2002 QM**	**2003 QM**	**2001 QM**	**2002 QM**	**2003 QM**
um	40	78	76	148	238	194	88	90	95
als	196	112	233	876	592	786	73	88	95
roducts	259	277	187	1510	1500	971	88	96	98
	43	21	31	77	81	79	54	90	86
asting	25	18	35	96	71	75	52	81	95
	79	59	71	238	178	151	45	75	80
	9	28	76	39	118	167	42	70	80
ure	4	15	189	45	100	545	11	80	28
m Ref.	206	120	36	417	466	122	63	90	86
cific S/T	*861*	*728*	*934*	*3446*	*3344*	*3090*	na	na	na
al Materials	80	22	74	239	86	207	70	60	75
& Controls	2	6	9	5	23	37	90	90	90
tion	na	21	34	na	103	106	na	-	60
D Subtotal	*82*	*49*	*117*	*244*	*212*	*350*	na	na	na
	39	44	40	54	61	58	na	na	na
nnov.	43	21	112	108	108	283	na	na	70
	16	9	45	98	44	121	na	na	100
actices	163	175	169	336	338	438	na	na	na
otal	*261*	*249*	*366*	*596*	*551*	*900*	na	na	na
sscut S/T	*343*	*298*	*483*	*840*	*763*	*1250*	na	na	na
	1204	1026	1417	4286	4107	4340	na	na	na

2-20-02

[1]The estimates of the percentage of the budget represented by the R&D projects analyzed are only approximate. Essentially, for each Planning Unit the sum of current-year funding for the projects analyzed is being compared to the total FY 2002 budget. Future GPRA studies will aim to improve the documentation of this funding data.

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 2003shell v5.3 06212002*.

Technology Impact Projections

The Office of Industrial Technologies (OIT) needs to understand the impact on energy use, waste production, and production cost each technology or project is likely to have. Estimating the potential benefits and impacts which may accrue from the results of research, development, demonstration (and related) projects is important for both existing and proposed projects. It is an important criterion in evaluating projects as well as in presenting the merits of both individual projects and, through aggregation, the overall portfolio of projects in a given area. The potential energy savings, types of energy saved, types of emissions reduced, and economic benefits are among the factors of importance.

Proposers responding to a Solicitation or Request for Proposals should review the governing documents for instructions on when and how to submit the necessary information; existing project managers/principle investigators should have received this request through an OIT program manager. A spreadsheet version of the Technology Impact Projection input forms and supporting information are on the same disk or e-mail you are using to read this message. It allows you to enter key information about your proposed technology and its expected market, and facilitates calculating the potential energy and emission reductions and other impacts of your project in a relatively rapid and consistent manner.

Please provide your best estimate for each piece of information required to complete the spreadsheet. 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". Placeholder values are included for some variables to (1) trigger the appearance of the Supplementary Table, which only appears if non-zero values are entered for use of feedstocks, renewables, waste, or “other” energy forms, and (2) illustrate where market data is entered on the sheet. These values must be changed to reflect your technology.

Per Unit Impact

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.

Unit Description

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.

Energy Use

Please provide energy use per year for the new and conventional units, by fuel. If feedstock energy use is expected to change, it should be accounted for under Other. Please also indicate the price of any feedstock, renewable, waste, and other fuels on the supplementary table. 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 distillate fuel, jet fuel, motor gasoline, residual fuel, liquid petroleum gas, and other petroleum.
> *Coal* - Includes metallurgical coal, steam coal, and net coal coke imports.
> *Feedstock* - Includes fossil fuels consumed in non-energy uses such as process feedstocks.
> *Renewable* - Includes the use of biomass (for energy or as feedstock), geothermal, solar, and wind energy.
> *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.
> *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.

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 renewable energy) and typical emissions factors for various fuels and electricity use. The spreadsheet contains emission factors for electricity and fossil fuels. You may enter emission factors for feedstocks, renewables, wastes, or other fuels needed to assess your technology on the supplementary table included with the spreadsheet system.

Please provide estimates for the non-energy-related waste production associated with the new and conventional technologies. Please specify what type of solid waste is being affected, if any.

> *Other Greenhouse Emissions Displaced*
> Estimate of the amount of greenhouse emissions other than CO_2, No_x, and VOCs if germane to your technology. These could include methane, perflourocarbons, or other gases. Identify which gas and insert the appropriate multiplier for that gas as provided in the attached tables. The spreadsheet

allows for three such other gases; if more are involved in your process, the carbon equivalent can be calculated separately, summed and inserted. An explanation should be provided.

Cost

Please provide rough estimates of the initial capital cost and non-energy variable costs associated with your technology new and old on a per-unit basis. Leave these blanks if you do not know the impact. Non-energy costs are non-fuel related annual costs that are affected by the technology substitution. This should include items such as operation and maintenance costs.

Market Projects and Impacts

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 Units in Total 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. Please also indicate for which year the data that you provided applies.

Overall Market Growth Rate
The default value is provided by OIT and based on EIA's projection of macroeconomic trends over future years. If your technology market will grow faster or slower, please provide a rationale for the value you enter.

Potential 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.

Market Penetration

To understand how rapidly the potential impact of the technology may be felt, the market penetration of the technology must be projected. Please indicate when the technology is likely to be introduced to the market on a commercial or similar basis. This date should be consistent with your technology development program plans. The date will normally occur 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.

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 (see Figure1). 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 judgement 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.

If your completed spreadsheet will be delivered in hardcopy only, please attach a copy of the completed Table I to the printout of the spreadsheet together with any supporting information. If your completed spreadsheet will be delivered in electronic form, please enter x's in the cells of

Table I instead of circling the hardcopy, save the changes, and deliver the instruction file (Tech Imp Projections4.wpd) as well as the completed spreadsheet file.

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 in site into selecting the appropriate penetration rate that might be expected for the new technology. The spread sheet, based on the unit performance, market size, and penetration rate class, will then calculate the estimated overall energy and environmental impacts and benefits over time which the new technology may bring to the industry and to the nation.

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.

You can circle the criteria that apply to your technology and identify which category fits best.

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

If you can think of good examples for your industry, we'll add them!

[1] An Enabling Technology