Summary of Findings – Peer Review of the FY2000 GPRA Assumptions

Report to
National Renewable Energy Laboratory

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List of Tables

Introduction

The Government Performance and Results Act (GPRA) requires federal agencies to establish performance goals for their programs. Programs within the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) develop goals through a process referred to as the GPRA data call, formerly known as the Performance Measurement and Quality Metrics data call. EERE systematically develops and confirms in an annual GPRA process and data call, credible, quantitative goals, both near term and longer-term, for the performance and impact of its programs. The goal of the EERE GPRA process is to measure, manage, and improve program performance and meet GPRA requirements for strategic planning and annual performance plans and reports.

Approach

Arthur D. Little worked with DOE staff to review the estimates and assumptions for selected Planning Units within four sectors of EERE. The review process is an interactive, iterative process between the individual Planning Unit managers and Arthur D. Little experts, in each case leading to a consensus regarding the final submissions. Arthur D. Little evaluated two primary metrics for the FY2000 data call:

- The energy and emission savings of each technology projected for the years 2000 through 2020, which depend on estimates of market penetration, cost, and performance assumptions for each technology.
- The performance measurements of each Planning Unit, which include near-term goals and milestones for the next five years designed to achieve the market penetration, cost, and performance objectives underlying the energy savings metrics.

With few exceptions, the discussions between Arthur D. Little and the Planning Units within EERE have resulted in agreement on revised program impact estimates and addition of related performance measures.

The 9 Planning Units reviewed for GPRA FY2000 include:

Office of Transportation Technology (OTT)
- Advanced Automotive Technologies

Office of Power Technologies (OPT)
- Photovoltaics
- High Temperature Superconductivity
- Hydropower

Office of Industrial Technologies (OIT)

- Glass Vision
- CFCC
- Metals Casting

Office of Building Technology and State/Community Programs (BTS)

- Residential Buildings Integration
- Commercial Buildings Integration

The majority of the Planning Units were selected based on the following criteria:

- large expected energy savings
- large program visibility
- significant variables impacting the Planning Units from last years analysis (e.g., the Presidents Million Roof Initiative in the Photovoltaic Planning Unit)
- desire to review all Planning Units every four years

The following tables summarize the results of the GPRA FY2000 analysis. In general, Arthur D. Little has seen improvement in the credibility of the GPRA information since working with DOE on this effort since 1994. Arthur D. Little has worked with the DOE staff to develop credible estimates/assumptions impacting energy saving and emission reduction estimates. Our overall findings are provided in Tables 1 through 4.

Table 5 shows the final energy savings estimates for all of the planning units for EERE. There may be some slight differences between Tables 1 through 4 and Table 5 due to revisions to estimates based on increased funding levels that occurred after the review. The final FY2000 program impact estimates may differ in some cases 2000 budget request since the revised numbers were estimated. In cases where a program did receive a FY2000 budget request increase, the revised submission served as the baseline for estimating the final program impact estimate.

Table 1: OTT Planning Unit Summaries

Advanced Automotive Technologies Planning Unit					
Advanced Automotive Technologies (EV, F/C, HEV, Adv. Heat Engines)					
	Total Primary Energy Displaced (Trillion BTU)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft*	0	2	401	N/A	1,128
Final Submission	0	32	639	1215	1,589
Electric Vehicles R&D					
Final Submission	0	2	12	17	19
Fuel Cell Powertrains R&D					
Final Submission	0	0	27	128	246
Hybrid Vehicle R&D					
Final Submission	0	21	270	547	712
Advanced Light Duty Heat Engine R&D (Advanced Diesel and SIDI)					
Final Submission	0	8	330	523	612
Advanced Diesel	*(0)*	*(0)*	*(220)*	*(328)*	*(383)*
SIDI	*(0)*	*(8)*	*(110)*	*(195)*	*(229)*

MAJOR FINDINGS FOR QM

- Overall market size, energy consumption, and emissions are consistent with trade group and government agency compilations and predictions.
- The predicted new sales of advanced automotive technology vehicles are consistent with industry capacity and change-over capability.
- The fuel economy goals for mature fuel cell powertrains as compared to mature hybrid electric vehicles (3.0x vs 2.0x) was recognized by the DOE analytical team as inconsistent. Revised targets assigning a 10% fuel economy premium to fuel cells as compared to hybrid electric vehicles (2.2x vs 2.0x) were used for the Final QM submission.
- For other advanced automotive technologies and vehicle classes, the fuel economy goals are reasonable.
- Vehicle cost estimates are aggressive, but within reasonable limits.
- The fuel economy goals for mature hybrid vehicles (using heat engines or fuel cells) are shy of the ultimate PNGV goal (2.2x vs 3.0x). Thus, the QM analysis seems somewhat conservative rather than overly optimistic.

MAJOR FINDINGS FOR PM

- The performance measures and key milestones are consistent with the overall QM forecasts, and the advanced automotive technology programs appear to be making good progress in all key areas.
- It would be useful to explicitly identify more detailed technological milestones.
- Several additional advanced technologies could play important roles for future transportation, and should be considered by the OTT.

DOE RESPONSES AND ACTIONS

- Agreement was reached with the DOE-OTT analytical team on reducing the fuel economy for the mature fuel cell powertrain vehicles to be more consistent with heat engine-powered hybrid vehicles. There are no additional major adjustments.

* Values included in *Program Analysis Methodology Office of Transportation Technologies Quality Metrics 2000* - preliminary draft November 1, 1998 (based on 10/1/98 results), prepared by OTT Analytical Team.

Table 2: OPT Planning Unit Summaries

Planning Unit					
Photovoltaics					
	Total Primary Energy Displaced (Trillion Btus)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft	.18	1.07	3.89	7.76	11.74
Final Submission	.25	1.20	6.00	18	49
	MAJOR FINDINGS FOR QM • It was very difficult to track the assumptions that were used to generate the photovoltaic GPRA numbers. Next year the program should make the analysis more transparent and clear • Spreadsheet data for system prices that were originally assumed were used in the GPRA analysis did not match estimates of system prices provided in the DOE/EPRI Technology Characterizations • The average PV system prices are reasonable for 2000. The 2005 and beyond system prices are aggressive, but achievable assuming volume installations of larger scale systems, major thin film and BOS advances, and module efficiency improvements • The O&M prices seem reasonable as do the capacity factor numbers • Next year, DOE might assume that tracking systems are used for some grid-sited distributed applications (substations etc.). A single axis, flat plate PV system in Phoenix, for example, will have a capacity factor of 33% vs. the 20.5% used in the analysis this year • The market penetration estimates appear conservative, especially for the years 2010 and beyond. The growth rate between 2015 and 2020, for example, is around 9%, which is very conservative. Beyond 2010 much more aggressive market penetration estimates are recommended • Some of the Million Solar Roof budget has been reinstated. Market penetration estimates in the early years should be slightly more aggressive due to the catalyst of the Million Solar Roof program. By 2005, PV costs for site based systems will achieve levels that begin to justify the installations, especially given the additional benefits of improved power reliability and enhanced flexibility. Increasingly favorable economics combined with financing flexibility such as rolling the cost into a home mortgage, will result in an accelerated rate of installation past 2005. **MAJOR FINDINGS FOR PM** • The performance measurement targets do not adequately address the milestones needed to achieve the PV market penetration targets. • Milestones should be set in terms of MW/yr goals of installations for each of the next five years. • Goals should be set to successfully manage the PVMat program's cost reduction goals. PVMat technical results (yields, efficiency, stability etc.) should be tied to manufacturing cost reduction objectives. • The year 2002 has no milestone targets. **DOE RESPONSES AND ACTIONS** • DOE agreed to modify the market penetration estimates to better reflect the partial reinstatement of the Million Solar Roof budget and the low system prices after the year 2005 • DOE provided additional inputs for the PM targets • DOE agreed to make the assumptions more transparent for the 2001 review					

Table 2: OPT Planning Unit Summaries (continued)

Planning Unit					
High Temperature Superconductivity (HTS)					
	Total Primary Energy Displaced (Trillion Btus)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft	0.0	0.01	0.16	1.75	8.04
Final Submission	0.0	0.0	0.13	1.79	8.51
	MAJOR FINDINGS FOR QM • The timeline between prototype demonstration and market penetration appears to be aggressive. The first year of market introduction was pushed backed 2 to 4 years. • The market adoption rates for HTS technologies appear to be conservative and were accelerated. • These two effects tend to offset each other and the overall numbers are similar to the DOE preliminary draft. **MAJOR FINDINGS FOR PM** • The link between PM and the program goals need to be strengthened. The goals include both increases in current carrying capacity as well as cost reductions for HTS technology. The PM concentrates on technology accomplishments with a scant mention of cost reduction milestones. • The adoption of HTS technologies is segmented along four markets: motors, generators, transformers, and cables. The milestones mention only achievements with motors and cables with no mention of generators. There needs to be milestone accomplishments for generators and transformers before these technologies are ready for commercial introduction and adoption. • Partnering with the private sector is projected to be more important in the out years, both in terms of funding levels and number of partners. PM should therefore reflect the increasing importance of private partnerships. **DOE RESPONSES AND ACTIONS** • DOE and ADL agreed to delay the first year of market penetration for HTS technologies. • DOE and ADL agreed to more aggressive market adoption scenarios.					
Planning Unit					
Hydropower					
	Total Primary Energy Displaced (Trillion Btus)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft	36	119	229	293	303
Final Submission	8	25	80	148	183
	MAJOR FINDINGS FOR QM • The adoption of the advanced turbine is segmented along three different markets: existing Federal facilities, existing private facilities that are up for FERC license renewal, and the potential for new capacity development. The potential market size for each segment is assessed individually.				

Table 2: OPT Planning Unit Summaries (continued)

Planning Unit	
Hydropower (continued)	
	MAJOR FINDINGS FOR QM (continued) • The numbers proposed by DOE represent the technical market potential for the advanced turbine program where the turbine can meet the technical requirement of the sites. An analysis needs to be conducted to assess the economic viability and the potential rate of adoption of the advanced turbine. • The adoption rates of the new turbine are aggressive for all market segments and should be scaled back. • New hydropower development potential is diminishing relative to past trends. The DOE preliminary numbers for new capacity additions are scaled back to reflect fewer new capacity developments and slower market adoption of the advanced turbine. **MAJOR FINDINGS FOR PM** • PM data is extremely limited and concentrates on the timeline of model testing and development. There is no mention of technical achievements of the model such as the amount of fish mortality and dissolved oxygen in the water. The program should add technical milestones for program activities that will help to reduce fish mortality or improve dissolved oxygen concentrations. • The program goal includes collaborations and increasing financial participation from private industries. The PM data should reflect the increasing importance of private partnership especially in the out years. **DOE RESPONSES AND ACTIONS** • DOE and ADL agreed to modify the projections for new capacity additions. • DOE and ADL agreed to modify the rate of technology adoption. DOE adjusted the preliminary draft numbers for the GPRA review. These estimates may now not agree with hydropower numbers submitted for other purposes.

Table 3: OIT Planning Unit Summaries

Planning Unit					
Glass Vision					
	Total Primary Energy Displaced (Trillion Btus)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft	-	22 (*2.8*)	40 (*6.2*)	53 (*12.*3)	65 (*20.2*)
Final Submission	-	23 (*2.8*)	40 (*6.2*)	56 (*12.3*)	73 (*20.2*)

Figures in parentheses are included in the totals but are attributable to end-use benefits of the glass products

GENERAL FINDINGS

- Eight of the most significant projects in the Glass Vision planning unit were reviewed.
- Savings projected from these eight projects range from about 10% of the energy use in the glass industry by the year 2005 to about 20% of projected energy use in the year 2020.
- Analysis and assumptions for the QM projections submitted in the initial submission were not well documented, but turned out to be reasonable based on subsequent discussions with the DOE program managers.
- Though significant errors were made in the calculation of the benefits (apparently in transcription of the assumptions to the spreadsheet), the errors almost completely canceled each other out, so that the final submission almost equals the original submission.
- Potential overlap between various projects will probably mean that not all the savings projected will be achieved if all projects are successful (i.e. if the savings from the first technology are 10%, the second technology has only 90% left to save from). This is particularly true for the glass melter and combustion technology-related programs. However, savings from projects not reviewed will likely off-set this double-counting to some extent. We believe that the approach chosen is a reasonable one, given the practical limitations for the GPRA analysis.
- PM milestones and goals were not clearly defined for each of the projects. We strongly recommend that they be included next year, as it is impossible to judge whether adequate progress will be made to justify the timelines assumed in the benefits' projections. We recommend that these PM milestones and goals, as well as go-no-go decision points and funding information be included in the templates during proposal evaluation to facilitate consistent portfolio evaluation and management.

MAJOR FINDINGS FOR QM

Diagnosis and Modeling of High Temperature Corrosion of Superstructure Refractories in Oxy/Fuel Glass Furnaces

- Energy savings appear realistic. However, a transcription error seems to have led to estimated energy usage numbers that are approximately a factor of 1000 too low. The proposal claims the fuel usage of 30 plants to be 6E11 Btu/year, i.e. 20 billion Btu/year per plant. However, energy use of the current technology is claimed as 16 million Btu/yr. We recommend that the numbers be changed accordingly. DOE agreed and the table above reflects these changes.
- Market size, share, and penetration assumptions appear reasonable given that this is not a technology as much as a method for applying technology

Table 3: OIT Planning Unit Summaries (continued)

Planning Unit	
Glass Vision (continued)	
	Development of Advanced Precursor Systems for On-Line Coating of Float Glass • The above table reflects energy benefits that apply to the end-use of the glass product, not to the manufacturing process. • A decimal point transcription error appears to have led to a serious underestimation of the market size (i.e. the annual output from a typical float glass plant is more than 108 ft2, even if not all float glass plants will sell coated glass). The error was recognized by DOE and corrected as shown in the table above. • Market introduction in 2000 (as proposed in the initial submission) appears unlikely, unless field demonstrations are already prepared. DOE agreed to change the market introduction to 2005. Changes are reflected in the table. • Market penetration class was not filled in, but should probably be b or c. DOE agreed and the changes are reflected in the table. **High Heat Transfer, Low Nox Natural Gas Combustion System** • The energy savings assumptions are reasonable • Market share appears unreasonably high, given the number of competitors. We recommend 50% as a more realistic figure. This change is reflected in the table above. **Integrated Ion Exchange Systems for High Strength Glass Products** • The above table reflects energy benefits that apply to the end-use of the glass product, not to the manufacturing process. • Market size and growth assumptions appear reasonable **Dynamic Expert Systems Control for Optimal Oxy-Fuel Melter Performance** • Energy use assumptions appear rather low. It was claimed that energy savings for this technology were calculated based on a $50-$60 million/yr cost savings. Assuming an average energy cost of $4 per thousand BTU, this would translate into savings of roughly 15 billion BTU/yr per unit. However, energy savings of 15 million BTU/yr per unit are reported. We recommend that the energy numbers be raised by 1000. This is reflected in the table above. • Market size and growth assumptions appear reasonable • 2000 market introduction appears unlikely given the R&D completion date of 2001. Given the nature of the technology (mostly software-based), we recommend 2002 as a more realistic date. DOE agreed to the change, which is reflected in the table above. **Synthesis and Design of Silicide Intermetallic Materials** • The P.I. was not able to provide energy usage numbers and did not substantiate assumptions. Because of the lack of data, the energy impacts of this technology have not been included in the table above. **Auto-glass process control** • The P.I. claimed a 10% reduction in energy usage for the proposed technology, but did not provide total energy usage numbers. Due to the lack of data, the benefits of this technology cannot be accurately assessed and were omitted from the table above.

Table 3: OIT Planning Unit Summaries (continued)

Planning Unit	
Glass Vision (continued)	
	Cullet Batch Preheater • The technology description mentions 15% energy savings, (which is reasonable), but the table shows a 40% savings. We recommend that the savings be adjusted to 15%. DOE recognized the inconsistency and the projections were changed accordingly, as reflected in the table. • A 1997 market introduction is incorrect. We recommend that this be adjusted to 1999. These changes are reflected in the table above. **MAJOR FINDINGS FOR PM** **Diagnosis and Modeling of High Temperature Corrosion of Superstructure Refractories in Oxy/Fuel Glass Furnaces** • Technical milestones and deliverables are reasonable and well documented. **Development of Advanced Precursor Systems for On-Line Coating of Float Glass** • No milestones were provided by the project P.I. Given this, the 2000 market introduction appears highly unlikely. As mentioned, the market introduction was modified. This inconsistency emphasizes the importance of having both QM and PM information for the programs reviewed. **Integrated Ion Exchange Systems for High Strength Glass Products** • Technical milestones and deliverables are reasonable and consistent with the anticipated commercialization date. **Dynamic Expert Systems Control for Optimal Oxy-Fuel Melter Performance** • Technical milestones and deliverables are reasonable. • As the development phase is expected to be complete by late 2001, a 2000 market introduction date is unlikely. We recommend 2002 as a more likely date. This change was accepted as discussed above. **PM data for other projects was not available for review. We strongly recommend that PM data be added in future.** **DOE RESPONSES AND ACTIONS** • Discussions were held with the Glass Vision Planning Unit and agreement was reached on making the recommended changes to the energy usage numbers and market introduction date. Two projects claimed that energy benefits would be derived from the end-use of the glass products rather than from their manufacture (Development of Advanced Precursor Systems for On-Line Coating of Float Glass and Integrated Ion Exchange Systems for High Strength Glass Products). Since these are OIT projects, the use of non-industrial QM's was questioned. However, it was decided not to adjust the numbers.

Table 3: OIT Planning Unit Summaries (continued)

Planning Unit					
CFCC					
	Total Primary Energy Displaced (Trillion Btus)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft	-	64	194	312	460
Final Submission	-	25	60	100	149

GENERAL FINDINGS

- Provides a good example of a cross-cutting program that effectively supports a core technology that can be applied across a broad range of industrial processes. The core technology is likely to have numerous further industrial applications.
- Analyses for GPRA submission and numbers were generally well documented, reasonable, and displayed a good understanding of the projects and their benefits by project managers and principal investigators. Nevertheless, a number of minor inaccuracies amounted to an overestimation of the benefits as is shown in the table above.
- DOE staff did their best to cooperate under the tight time schedule and were generally quite knowledgeable of their projects.
- The diversity of CFCC applications suggests that little or no overlap will exist between energy savings of different elements of the programs. In fact, other spin-off applications that are not yet considered are likely to occur.
- Performance measures generally show a logical succession of overall program activities with reasonably defined milestones and goals. However, for future submissions and for portfolio management we recommend a slightly more detailed description of the performance metrics. We recognize that such metrics do exist within the individual programs, but an organized central overview of them would probably be very beneficial. Preferably they would be included on the template for collection.

MAJOR FINDINGS FOR QM

Ceramic Turbine Components

- Assumptions on energy savings, market size, and technology classification are generally reasonable and well documented
- Savings are not strictly accrued in industry as large turbines like these are primarily used in power generation in utilities currently
- The projected market growth rate of 14% is unrealistically high, as it is doubtful whether this can be sustained over a 20-year period. A more conservative rate of 5 or 6% is recommended. DOE has agreed to these changes. This is reflected in the table above.

Infrared Burners

- Total market, market share, market penetration, and cost and equipment life assumptions are reasonable and in line with information
- Assumptions of energy savings per burner are assumed at 40%, which is the high end of the range (25-40%) indicated. While 40% is probably achievable in some applications, in others there will not be any energy savings (especially in comparison with electric IR systems). Therefore a lower energy savings number should be used across the board (30% seems reasonable). DOE has agreed to lower these savings to 30%. This change is reflected in the table above.
- The targeted markets are textiles, paper, paints, and coatings, none of which industries have a four- percent growth rate. Two percent would seem more reasonable. DOE agreed to the more conservative assessment that is reflected in the table above.

Table 3: OIT Planning Unit Summaries (continued)

Planning Unit	
CFCC (continued)	
	Ceramic Furnace Fan • Assumptions on energy use, cost, life, and market estimates seem reasonable. **Hot Gas Filters** • Assumptions for energy savings are reasonable • Is the market meant to just represent industrial sites or power generation in general? Assumptions for market size are reasonable, although it would be better to use a plant as a unit, rather than a filter (you can't install 1/5000 of a plant!). As these suggestions would not affect the ultimate outcome, no changes to the analysis were recommended. • Market share may be optimistic, as the technology will probably also compete with high temperature sintered alloy filters. Given the significant debate over the relative merits of various filter types for these applications, it was decided not to make changes to the analysis. • As the technology requires the switch to APFBC technology, which requires very major investments in plant with a life of 25 –40 years, the classification of the technology as b (full market penetration within 10 years) seems too aggressive, especially when considering the history of alternative coal-based power generation technologies. Class c (full market penetration within 25 years) would appear more appropriate. DOE agreed to these changes and they are reflected in the table above. **Immersion Tube Burners** • The assumptions for energy consumption appear reasonable, but there appears to be an error in the calculation involving natural gas usage for the conventional and proposed technologies: 2 billion lbs/yr /2000 lbs/ton *9 million BTU/ton (natural gas) /1000 BTU / 3100 units = 0.0029 BCF/yr, compared with 1.16 BCF/yr reported in the input spreadsheet. We recommend that this error be corrected and DOE agreed. This is reflected in the table above. • Energy savings of 36% are quoted, but it is not clear what that is compared with. It appears unlikely that identical savings can be achieved compared with competing gas and electric technology (i.e. what is the baseline). DOE explained satisfactorily that the savings are a weighted composite of the savings achievable compared with gas and electric technology. • Assumptions on market size and share appear reasonable. **Radiant Burners** • Assumptions on energy use, cost, life, and market estimates seem reasonable • Assumptions on the magnitude of energy savings appear reasonable (assuming higher emitter temperature is the cause for these savings), although it is not stated explicitly what causes the higher efficiency. DOE confirmed that the higher emitter temperature is the reason for the increased efficiency. **MAJOR FINDINGS FOR PM** **Ceramic Turbine Components, IR Burners, Hot Gas Filters, Immersion Tube Burners, and Radiant Burners** • Goals and milestones are reasonable and lead to the targeted commercialization date. A bit more detailed description would be valuable. I.e. aspects to be proven in field test.

Table 3: OIT Planning Unit Summaries (continued)

Planning Unit	
CFCC (continued)	
	Ceramic Furnace Fans • Performance Measures are not reported. Nevertheless, in the template, there is mention of a two-year demonstration program **DOE RESPONSES AND ACTIONS** • Discussions were held with the CFCC Planning Unit and agreement was reached on the proposed changes. Specifically, the market growth rate for the Ceramic Turbine Components project was lowered from 14% to 6%; the energy usage numbers for Immersion Tubes were corrected; and the energy efficiency increase for IR Burners was changed to 30%.

Planning Unit					
Metals Casting					
	Total Primary Energy Displaced (Trillion Btus)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft	-	11	26	55	89
Final Submission	-	8	20	46	77
	GENERAL FINDINGS • Analyses for GPRA submission and numbers were generally well documented, reasonable, and displayed a good understanding of the projects and their benefits by project managers and principal investigators. Nevertheless, a number of minor inaccuracies amounted to a slight overestimation of the benefits as is reflected in the table above. • DOE staff did their best to cooperate under the tight time schedule and were generally quite knowledgeable of their projects. • The savings projected above represent a reduction of almost 20% in the year 2020. In earlier years the savings are substantially lower. • Given the large number of projects in the metals casting vision there is some potential for overlap between various projects that may cause some double-counting if all projects are successful (i.e. if the savings from the first technology are 10%, the second technology has only 90% left to save from). However, savings from projects not reviewed will likely offset this double counting to some extent. We believe that the approach chosen is a reasonable one, given the practical limitations for the GPRA analysis. • Performance Measures generally show logical succession of overall program activities with reasonably defined milestones and goals. However, for future submissions and for portfolio management we recommend a slightly more detailed description of the performance metrics. We recognize that such metrics do exist within the individual programs, but an organized central overview of them would probably be very beneficial. Preferably they would be included on the template for collection.				

Table 3: OIT Planning Unit Summaries (continued)

Planning Unit	
Metals Casting (continued)	
	MAJOR FINDINGS FOR QM **Gating of Aluminum Permanent Mold Castings,** **In-Stream Inoculation for Aluminum Alloy Casting Processes** **Reengineering of Steel Casting Manufacturing** **Predicting Pattern Tooling and Casting Dimensions for Investment Casting** **Clean Steel: Mach. of Clean Cast Steel; and Accelerated Transfer of Clean Steel Technology** **Steel Foundry Refractory Lining Optimization: EAFs** **Mold Materials for Permanent Molding** **Thin Wall Cast Iron** • Assumptions on energy savings, market size, competing technologies, and technology classification are reasonable **Die Materials for Critical Applications** • Assumptions on market size, and technology classification are generally reasonable and well documented • Energy savings are based on the assumption that foundries using this technology totally switch from using virgin aluminum to secondary aluminum. This may be too optimistic. No changes were made. **Enhancements in Magnesium Die Casting** • Assumptions on energy use and technology class are reasonable. • The target market needs to be better defined. It is claimed that this technology will result in an increased use of magnesium (over ferrous materials) in automotive parts, and that energy savings would result from the lower energy requirements of magnesium smelting. An appropriate target market might be to quantity of ferrous auto parts that could potentially be displaced by magnesium. However, the current target market was defined as the quantity of magnesium currently produced for the automotive sector. Probably, this analysis is more conservative than necessary. No changes were made. • Energy usage numbers appear to be high due to a few errors in the calculation (assumptions are reasonable). The unit is defined as one automobile with 250lb of replaceable castings. If ferrous castings require 41 million BTU/ton cast, then the energy usage for current technology is 41E+06 BTU/ton x 250 lb/2000 lb per ton = **5.125 million BTU/unit**. The specified energy usage for the current technology is 6000 kWh x 10,500 BTU/kWh + 20,000 cf x 1,030 BTU/cf = **83.6 million BTU/unit**. We recommend that the energy usage numbers for the current and proposed technologies be scaled down by a factor of 16.3 (from 83.6/ 5.125). These changes were agreed to by DOE and are reflected in the table above.

Table 3: OIT Planning Unit Summaries (continued)

Planning Unit	
Metals Casting (continued)	
	Optimization of the Squeeze Casting Process • Assumptions on energy use and technology classification are realistic and well documented • The target market needs to be better defined. It is claimed that this technology will result in an increased use of aluminum (over ferrous materials) for load-bearing automotive parts, and that energy savings would result from the lower energy requirements of aluminum smelting. An appropriate target market might be the quantity of ferrous load-bearing auto parts that could potentially be displaced by aluminum. However, the current target market was defined as the quantity of aluminum currently produced for the automotive sector. It is likely that the impact (if any) on the projections would be modest. No changes were made. • Energy usage numbers appear to be high due to some computational errors (assumptions were reasonable). The unit is defined as one automobile with 300lb of replaceable castings. If ferrous castings require 41 million BTU/ton cast, then the energy usage for current technology is 41E+06 BTU/ton x 300 lb/2000 lb per ton = **6.15 million BTU/unit**. The specified energy usage for the current technology is 6000 kWh x 10,500 BTU/kWh + 20,000 cf x 1,030 BTU/cf = **83.6 million BTU/unit**. We recommend that the energy usage numbers for the current and proposed technologies be scaled down by a factor of 13.6 (from 83.6/ 6.15). These changes were agreed to by DOE and are reflected in the table above. **Fast Response Measurements of Internal Die Cavity Temperatures** • Energy usage and market assumptions appear realistic • The market introduction date of 2000 is a little optimistic. We recommend a more conservative date such as 2002. These changes were agreed to by DOE and are reflected in the table above. **Casting Characteristics of Al Die Casting Alloys** • Energy savings assumptions are realistic • Since the project report is to be written in late 2000, a market introduction in that same year seems unlikely. A more reasonable date is 2002. These changes were agreed to by DOE and are reflected in the table above. **Qualitative Reasoning for Diecasting Design Applications** • Energy usage assumptions appear reasonable • The key deliverable, i.e. the final version of the software, is expected to be ready by late 2000, in view of this a market introduction date of 2000 is optimistic. 2002 would be more realistic. These changes were agreed to by DOE and are reflected in the table above. **Non Incineration Treatment to Reduce Benzene** • The energy usage and energy savings assumptions appear reasonable • Considering the technical milestones, the market introduction year of 2000 seems optimistic. We recommend 2002 as a more likely date. These changes were agreed to by DOE and are reflected in the table above. **Yield Improvement in Steel Casting (Yield II)** • Assumptions on energy savings, market size, and technology classification are generally reasonable and well documented • It seems unlikely that this technology will be introduced to the market by 2000. We recommend 2002 as a commercialization date. These changes were agreed to by DOE and are reflected in the table above. **Systematic Microstructural & Corrosion Performance Evaluation** Although the technological benefits are not clearly specified, the underlying energy assumptions seem reasonable.

Table 3: OIT Planning Unit Summaries (continued)

Planning Unit	
Metals Casting (continued)	
	MAJOR FINDINGS FOR PM Gating of Aluminum Permanent Mold Castings, **Die Materials for Critical Applications,** **Enhancements in Magnesium Die Casting,** **Optimization of the Squeeze Casting Process ,** **Predicting Pattern Tooling and Casting Dimensions for Investment Casting,** **Thin Wall Cast Iron** • Deliverables and milestones are reasonable and consistent with the projected commercialization date **In-Stream Inoculation for Aluminum Alloy Casting Processes,** **Reengineering of Steel Casting Manufacturing,** **Clean Steel: Mach. of Clean Cast Steel; and Accelerated Transfer of Clean Steel Technology,** **Systematic Microstructural & Corrosion Performance Evaluation** **Steel Foundry Refractory Lining Optimization: EAFs** • Deliverables and milestones seem reasonable, although details regarding the technology transfer process are lacking **Fast Response Measurements of Internal Die Cavity Temperatures** • Milestones for the bench-scale and full-scale demonstrations of the product seem reasonable. • Considering the uncertainties in the technology transfer process, a later market introduction date is more likely. We suggest 2002 as a more realistic date. **Casting Characteristics of Al Die Casting Alloys** • The steps and milestones leading to full commercialization are lacking. This makes the year of market introduction somewhat uncertain. In view of this, we suggest a later date such as 2002. **Mold Materials for Permanent Molding** • Deliverables seem reasonable, although details regarding the technology transfer process are lacking **Qualitative Reasoning for Diecasting Design Applications** • Deliverables and milestones are reasonable • The projected commercialization date of 2000 is somewhat aggressive. We recommend 2002 as a more likely date. **Non Incineration Treatment to Reduce Benzene** • The technical deliverables that will follow the laboratory and plant trials are not outlined. • Considering the uncertainties in the technology transfer process, a later market introduction date is more likely. We suggest 2002 as a more realistic date. **Yield Improvement in Steel Casting (Yield II)** • Deliverables seem reasonable, although details regarding the technology transfer process are lacking • Considering the uncertainties in the technology transfer process, a later market introduction date is more likely. We suggest 2002 as a more realistic date. **DOE RESPONSES AND ACTIONS** • Discussions were held with the metals casting planning unit and agreement was reached on the proposed changes to the energy usage numbers and market introduction dates.

Table 4: BTS Planning Unit Summaries

Planning Unit					
Commercial Buildings Integration					
	Total Primary Energy Displaced (Trillion Btus)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft	8.3	66.0	200.1	377.0	525.4
Final Submission	9.5	69.7	207.3	386.3	535.4

	MAJOR FINDINGS FOR QM
	• Overall, the DOE/BTS numbers seem reasonable. Increases from the Preliminary Draft to the Final Submission represent increases in the level of funding for this planning unit
	• Savings are a combination of model energy code adoption and voluntary programs. Building codes were the primary method of achieving savings (represents 80% of the savings).
	• The market penetration for Commercial Buildings Research and Development program is approximately 1% by 2020. This is conservative.
	• The market penetration for Commercial Codes reaches a maximum of 36% by 2010. However, due to backsliding on adoption, market penetration drops down to 21% by 2020. This appears reasonable.
	• A detailed account of the 30% energy savings shows a variety of activities, including:
	  • building codes (which, according to DOE-2 simulation runs, reduce the energy used by 20%),
	  • automated building systems (some studies have shown commercial buildings can save up to 10% or more of the energy used)
	  • a new way of constructing buildings, using the "whole building" system approach at the design state so that all components of buildings are chosen to work together (e.g. proper sizing of equipment).
	  • However, none of this is documented by technology or in detail, which would help in the evaluation.
	
	MAJOR FINDINGS FOR PM
	• The performance measures were provided through 2004. The review pertains only to these performance measures.
	• All of the milestones and planned milestones deal with the adoption of building codes. Given that the majority of savings associated with the Planning Unit are through codes, these milestones appear appropriate and consistent with the goal of the Planning Unit.
	• One planned activity would be to include a verification procedure to insure the Commercial Codes are being enforced and that the energy savings are being achieved.
	
	DOE RESPONSES AND ACTIONS
	• The findings have been discussed with Donna Hostick, PNL. It was agreed additional documentation should be provided by BTS.
	• The reviewer agreed the BTS estimates appear reasonable, no revisions to the metrics were undertaken					

Table 4: BTS Planning Unit Summaries (continued)

Planning Unit					
Residential Buildings Integration					
	Total Primary Energy Displaced (Trillion Btus)				
	2000	**2005**	**2010**	**2015**	**2020**
Preliminary Draft	1.5	37.8	125.2	230.2	322.9
Final Submission	1.6	39.6	131.2	242.0	340.7
	MAJOR FINDINGS FOR QM • Overall, the DOE/BTS numbers seem reasonable. Increases from the Preliminary Draft to the Final Submission represent increases in the level of funding for this Planning Unit • Savings are a combination of residential energy code adoption and voluntary programs. The savings are distributed evenly. • The GPRA submittal shows homes using 30% less energy in 1999 and 50% less energy in 2004 relative to typical homes in 1990. • No technical justification for either the 30% or 50% has been offered. A list of technologies that can be universally applied needs to be documented to show the level of energy savings technically feasible. The 30% and 50% levels are not out of the realm of possibility, but they are aggressive and the actual path to these savings needs to be documented. • The energy savings are assumed for space conditioning and water heating end-uses only, since no other measures or technologies are discussed. It is not clear from DOE's submittal what technologies provide savings (i.e. insulation, furnace, a combination, etc.). • 70% market penetration by 2010 is a typographical error – it should be 10%. The 10%, as well as the 4% in 2004, would appear to be conservative estimates for market penetration. **MAJOR FINDINGS FOR PM** • Measures are consistent with goals for new construction, however they do not support the level needed for the savings projected in the QM. • Additional measures for existing building stock, other than low-income housing, would paint a clearer picture of how the program's goals are going to be realized in this area. • The program has a stated goal of 250,000 cumulative homes by 2004, yet when homes cited in the milestones section are summed, they represent one-tenth of 250,000. Better documentation is needed to justify the additional homes, but the number appears reasonable, since it represents approximately 4% of all homes constructed in this time period. **DOE RESPONSES AND ACTIONS** • The findings have been discussed with Donna Hostick, PNL. It was agreed additional documentation should be provided by BTS. • The reviewer agreed the BTS estimates appear reasonable, no revisions to the metrics were undertaken.				

Table 5: Final Planning Unit Submission

Planning Unit	*Total Primary Energy Displaced (Trillion Btus)*		
	2000	**2010**	**2020**
BTS			
Commercial Buildings Integration	10	207	535
Community Partnerships Program	8	225	434
Energy Star	3	106	210
Equipment, Materials & Tools	36	1,369	3,542
Residential Buildings Integration	2	131	341
State Energy Program	6	56	99
Technology Roadmaps and Competitive R&D	0	100	347
Weatherization Assistance Program	7	96	184
OIT			
Advanced Materials (CFCC and AIM)	0	93	237
Aluminum Vision	0	49	187
Chemicals Vision	0	151	830
Cogeneration - CHP	27	198	435
Forest & Paper Products Vision	0	194	1,508
Glass Vision	0	40	73
IAC	71	93	99
Integrated Delivery Program	27	158	331
Inventions & Innovations	112	107	117
Metals Casting Vision	0	20	77
NICE-3	19	109	144
Petroleum Refining Vision	0	218	340
Steel Vision	0	36	110
OPT			
Biomass Power R&D	28	422	533
Energy Storage	0	1	1
Geothermal Energy R&D	56	182	248
High Temperature Superconductivity	0	0	9
Hydrogen (Fuel Cell)	4	92	642
Hydropower	8	80	183
Open Solicitation	1	3	3
Photovoltaic Systems R&D	0	6	49
Power Systems Integration	23	124	132
Solar Buildings	3	30	112
Solar Thermal	0	4	29
Wind Energy R&D	20	207	613
OTT			
Advanced Automotive Technologies	0	639	1,589
Biofuels	0	360	1,001
Heavy Duty Vehicle Technologies	6	203	396
Transportation Materials Technology	0	12	50

The final FY2000 program impact estimates may differ in some cases from the "revised submissions" contained in Tables 1–4 due to increases in the FY2000 budget request since the revised numbers were estimated. In cases where a program did receive a FY2000 budget request increase, the revised submission served as the baseline for estimating the final program impact estimate.