Summary of Findings

Peer Review of the FY '03 GPRA Assumptions

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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. 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 areas for the FY2003 data call:

- The energy and carbon emissions savings of each technology projected for the years 2003 through 2030, 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.

The discussions between Arthur D. Little and the Planning Units within EERE have resulted in agreement on revised program impact estimates and related performance measures for the Planning Units reviewed.

The five Planning Units reviewed for GPRA FY2003 include:

Office of Transportation Technologies (OTT)
- Advanced Combustion Engine R&D

Office of Industrial Technologies (OIT)
- Forrest Products – Black Liquor and Solid Biomass Gasification
- Industrial Materials for the Future

Office of Building Technologies, State and Community Programs (BTS)
- Equipment Materials and Tools (R&D component)

Office of Power Technologies (OPT)
- Wind

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

- desire to review all Planning Units every four years
- large expected energy savings
- large program visibility
- significant changes in a Planning Unit from previous year

The following tables summarize the results of the GPRA FY2003 analysis. In general, Arthur D. Little has seen improvement in the credibility of the GPRA information while working with DOE on this effort since 1994. Arthur D. Little has worked with the DOE staff to develop credible estimates/assumptions impacting energy savings and emissions reduction estimates. Our overall findings are provided in Tables 1 through 5. Table 6 shows the energy savings estimates for EERE programs based on preliminary budget request levels for FY2003. A significant change in program funding levels would alter energy savings estimates.

Office of Transportation Technologies

Table 1: OTT Planning Unit Summaries

Planning Unit							
Advanced Combustion Engine R&D							
	Total Primary Energy Displaced (Trillion BTUs)						
	2003	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Preliminary Draft	0	1	134	339	471	521	571
Final Submission	0	1	134	339	471	521	571
	Total Primary Oil Displaced (Trillion BTUs)						
Preliminary Draft	0	1	134	339	471	521	571
Final Submission	0	1	134	339	471	521	571

MAJOR FINDINGS FOR ESTIMATED BENEFITS

- The energy savings targets set for 2010, 2020, and 2030 represent significant benefits, consistent with projected consumption levels.
- OTT's method of estimating potential fuel savings from engine efficiency improvements for light and heavy-duty vehicles is well thought-out, accounting for consumer preference and vehicle market size.
- 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.
- Energy savings are consistent with Advanced Combust. Engine R&D eff. goals.
- Improved vehicle fuel efficiency – for both light and heavy-duty vehicle - is an important strategy to achieve decreased oil and energy consumption. The EIA reference fuel efficiency, however, is somewhat difficult to follow. DOE may consider using another metric for the quantification of vehicular fuel efficiency.

MAJOR FINDINGS FOR PLANNING UNIT PERFORMANCE MEASURES (PM)

- The metrics listed in the Advanced Combustion Engine R&D program budget were reviewed with respect to feasibility and impact on energy savings. OTT's Program Analysis Methodology was also reviewed for this effort. The general findings of this review are that the PMs are well defined and represent meaningful advances in combustion engine technology.
- In addition to Arthur D. Little (ADL), this evaluation solicited comments from combustion engine manufacturers to include the industry perspective.
- Unit PMs are broadly defined, including emissions, durability, and health impacts, in addition to efficiency measures. The inclusion of these parameters will ease technology implementation, as the goals considered issues of technological improvements and practical use.
- Unit PMs are primarily focused on energy and oil displacement through diesel engine technology. No goal explicitly addresses spark-ignited engine technology, which dominates light-duty vehicles.

DOE RESPONSES AND ACTIONS

- DOE is in general agreement with the review and realizes that several goals are aggressive, but reflects new efforts to promote programs and technologies.
- DOE notes that these goals may be revised at a later time if sufficient progress is not made, but it wants to be as progressive as possible for the time being.

Forest Products – Black Liquor and Solid Biomass Gasification

Table 2: OIT Planning Unit Summaries

Planning Unit							
Black Liquor and Solid Biomass Gasification							
	Total Primary Energy Displaced (Trillion Btus)						
	2003	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Preliminary Draft	0	0	176	509	1,168	2,189	3,128
Final Submission	0	0	107	311	713	1,336	1,909

MAJOR FINDINGS FOR ESTIMATED BENEFITS

- The resubmitted energy saving estimates represent a starting point for a more detailed analysis of the benefits using gasification technology for black liquor recovery and solid biomass residue power generation. DOE recognizes that a more detailed analysis is required with input from the pulp & paper industry to obtain a more accurate estimate of both the technical market potential and likely introduction rates. Arthur D. Little (ADL) has recommended a methodology to refine the estimate of the impact of gasification technology on the pulp & paper industry. DOE expects that a more detailed analysis will be conducted to improve future GPRA estimates.
- The resubmitted quality metrics are a result of adjusting the estimate of the technical market potential for gasification. As a starting point, the potential for substituting gasification for black liquor recovery and solid biomass residue power generation for the pulp and paper industry was used. Changes were made to both the average size of a mill and the additional power available for export when converting to gasification from Thomlinson boilers. Minor adjustments were made to the annual capacity factor (on-line factor) of the mill and the technology introduction year.
- A major uncertainty in the quality metrics is the degree to which gasification technology would be used for other forest products industry residues (i.e., outside the pulp & paper industry), as this increases the technical market potential. DOE should include an analysis of these markets as part of its refinements.
- An additional uncertainty in the benefits estimation is the degree to which existing pulp & paper mills can import the necessary additional biomass required for power generation when gasification replaces combustion (mill thermal energy needs necessitate this when gasification is used instead of combustion). Inputs will also be required from the pulp & paper industry on likely future steam/electricity load balances in the out-years, as this affects the overall impacts of gasification.
- The impacts of biotechnology on the quality of feedstock for paper mills in the future also need to be considered as that will impact the amount of biomass available for energy relative to the biomass used to produce pulp (e.g. the ratio of lignin to cellulose to hemicellulose may change over time).
- It is important to include point source emission reductions in addition to the displacement of grid-associated emissions, because gasification based power is cleaner than combustion (e.g. NOx emissions).
- As DOE awards projects for gasification, it is important for DOE to qualify what the role of the DOE funding is and its impact on energy savings and other benefits.
- The *Industrial Materials of the Future* Planning Unit has claimed a portion of the

Planning Unit	
	energy reduction benefits for implementation of gasification through development of advanced refractories. The final roll-up of OIT benefits should reflect this sharing of benefits among Planning Units. **MAJOR FINDINGS FOR PLANNING UNIT PERFORMANCE MEASURES (PM)** • ADL did not receive any PM for review. **DOE RESPONSES AND ACTIONS** • In response to ADL's concerns that the initial energy savings estimates were too high, DOE revised the estimate in line with recommendations. • DOE also indicated that they are planning to conduct a more detailed market analysis for FY'04 that will consider, to the extent that funding permits, ADL's various recommendations.

Table 3: OIT Planning Unit Summary – Industrial Materials for the Future

Planning Unit							
Industrial Materials for the Future (IMF)							
	Total Primary Energy Displaced (Trillion Btus)						
	2003	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Preliminary Draft	NA	42	99	182	290	407	535
Final Submission	NA	31	74	133	207	284	362

MAJOR FINDINGS FOR ESTIMATED BENEFITS

- The method of using a cohort of projects for a bottom-up estimate of energy savings is reasonable.
- It should be noted that the IMF unit claims energy savings that may be claimed in other OIT planning units such as chemicals, glass, aluminum, steel and forest products. For example, energy savings were claimed from refractory materials for gasifiers for applications using black liquor and biomass. The gasification piece of the Forest Products Planning Unit also claims energy savings from implementation of gasification technology for black liquor and biomass. The final roll-up of OIT energy savings should handle double counting.
- DOE should work with the principal investigators to improve the GPRA estimates by including detailed assumptions and methods used. Particular emphasis should be placed on:
  - How the energy savings are achieved by using the material/technology compared to current practice
  - Estimates of technology introductions should take into account the likely time required for technology development, introduction and commercialization
  - Non-energy savings such as productivity increases
  - Identifying what portion of the total energy savings is attributed to the material

MAJOR FINDINGS FOR PLANNING UNIT PERFORMANCE MEASURES (PM)

- The objective of IMF is to conduct R&D to develop new materials consistent with the needs identified in the Industry of the Future (IOF) visions/technology roadmaps, and significantly reduce energy use in the energy-intensive IOF industries.
- A draft version of the FY'03 budget document for Enabling Technologies contained a PM based on energy intensity. No quantitative PM was given in the document.

DOE RESPONSES AND ACTIONS

- DOE provided background information for all of its projects. Additional assumptions and methods will be included in the FY'04 GPRA submission.
- The savings calculations for most of the DOE projects are fully attributable to materials improvements. For the remaining projects, DOE will attempt (in FY'04 GPRA) to identify the portion of savings attributable to materials improvement. However, DOE believes that the integrated nature of some projects will make it difficult, if not impossible, to calculate credible "partial" savings estimates.
- DOE adjusted the year of commercial introduction for some of its projects. Additional information on development times required for commercialization will be considered for the FY'04 GPRA submission.
- DOE is developing a full set of PM for the FY'04 cycle.
- DOE acknowledged that IMF activities at RAND, ORNL, and NREL provide additional information for estimating program benefits.
- The refinements to the processes noted in bullet three above are underway at DOE.

Table 4: BTS Planning Unit Summary

Planning Unit										
Equipment, Materials, and Tools (EMT)										
	Total Primary Energy Displaced (Trillion Btus)*									
	2003	**2004**	**2005**	**2006**	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
Preliminary Draft	12	27	44	66	96	249	729	1401	2117	2849
Final Submission	12	29	59	94	138	368	866	1359	1696	1993

MAJOR FINDINGS FOR ESTIMATED BENEFITS

- NOTE: The above QM figures include estimated savings for all of the programs administered by the Equipment, Materials, and Tools (EMT) Planning Unit. ADL was asked to review only the R&D programs, which represent approximately 80% of all EMT energy savings through 2030.
- FY'03 QMs for the EMT planning unit's R&D programs are based on their impact on the development and market uptake of 17 technologies in 4 program areas, plus the energy savings generated by the adoption of DOE design tools and the impacts of competitive R&D funding.
- In general, QMs for public R&D programs follow two basic tracks depending on whether the technology would have been developed without the program, but brought to market in less robust form or at a later date, or would not have been developed at all. If the technology would likely not be developed without public support, then all future QM impacts can be credited as resulting from the program. If the program merely accelerates development that would likely occur later, then the QM impacts should be modeled as diminishing over time as the projected effects of future alternative deployment are accounted for.
- While consistent with other PMs, the Preliminary Draft QM figures reflected treatment of only advanced commercial refrigeration as accelerating market development, but did not show diminishing returns for other technologies that are also likely candidates for private sector development. This resulted in greater overall long-term savings than justified.
- ADL recommended adjusting the models to reflect the accelerated times to market identified as PMs for the other technologies.

MAJOR FINDINGS FOR PLANNING UNIT PERFORMANCE MEASURES (PM)

- The basic indicators used to assess EMT R&D program effectiveness are energy performance, marketability, and time to market. The PMs identified for the programs are generally reasonable and capable of generating appropriate and consistent QM results.

DOE RESPONSES AND ACTIONS

In response to ADL's recommendations, DOE reviewed the models for each of the EMT R&D Programs to ensure that they properly accounted for acceleration of technological developments likely to occur without DOE support. In the Final Submission numbers, the lower projections reflect the diminishing returns attributable to such programs over the long term. The Final submission also includes additional savings from duct seal and insulation elements added to Residential HVAC Distribution System and other minor corrections.

***Starting from a base year of 2001.**

Table 5: OPT Planning Unit Summary

Planning Unit							
Wind							
	Total Primary Energy Displaced (Trillion BTU/yr)						
	2003	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Preliminary Draft	20	50	800	1,450	2,100	2,800	3,450
Final Submission	20	50	550	1,100	1,700	1,950	2,100

MAJOR FINDINGS FOR ESTIMATED BENEFITS

- The wind energy capacity factor estimates assumed by DOE seemed optimistic. The potential for 0.50 capacity factors within 10 years at Class 6 sites, however, was generally accepted by turbine designers contacted, assuming less aggressive reductions in installed system costs to account for increased hub height and stronger towers. To support this, DOE provided higher than average installed system costs when running the analysis.
- ADL and DOE ran sensitivities with the NEMS model to compare the impact of these capacity factor and system cost changes. These sensitivities showed minimal difference in the overall total primary energy displaced.
- The original NEMS runs were done in Spring 2001 when industry and DOE expected a five-year extension of the Production Tax Credit (PTC) that was later obviated by September 11, 2001 concerns. The National Energy Policy Plan (May 2001) and Administration request for FY'02 supports an unspecified length of PTC extension. Updated runs were made with a one-year extension that is expected to pass, retroactively, in early FY'02.
- DOE provides total primary energy displaced calculations for Class 6 and Class 4 winds. Inputs into the NEMS model takes a weighted average of the two to provide a single entry. The early year ratio of Class 6 to Class 4 winds was weighted slightly too heavily toward Class 4 winds relative to industry estimates.

MAJOR FINDINGS FOR PLANNING UNIT PERFORMANCE MEASURES (PM)

- The two cost of energy (COE) PM one for Class 6 and one for Class 4 wind turbines, are reasonable in magnitude and in achievement date.
- COE is the driver for wind development activity and it embodies reductions in capital equipment cost and increases in capacity factor. In addition, COE is easily understood across the electricity generation sector. However, the DOE impact or influence on financing assumptions built in to COE calculations is minimal.
- Planned accomplishments that indicate research, testing, and verification activities in support of the COE PM goals should be more clearly defined.
- The program includes small-scale wind turbines, and should therefore add PMs and planned accomplishments to guide this work.

DOE RESPONSES AND ACTIONS

DOE agreed to the adjustments suggested by ADL, which resulted in lower estimates of energy savings beyond 2005.

Table 6. EERE GPRA 2003 Metric Estimates

Sector/Planning Unit	*Total Primary Energy Displaced (Trillion Btus)*		
	2005	*2010*	*2020*
BTS			
Commercial Buildings Integration	4	42	239
Community Energy Program	122	202	353
Energy Star Program	41	169	568
Equipment, Materials & Tools	**59**	**368**	**1,359**
Residential Buildings Integration	1	12	74
State Energy Program	12	28	48
Weatherization Assistance Program	25	66	123
OIT			
Vision Industries	329	933	3,091
Agriculture Vision	61	189	545
Aluminum Vision	17	76	194
Chemicals Vision	96	233	786
Forest & Paper Products Vision	**32**	**187**	**971**
Glass Vision	15	31	79
Metal Casting Vision	21	35	75
Mining Vision	41	76	167
Petroleum Refining Vision	17	36	122
Steel Vision	30	71	151
Enabling Technologies	48	118	350
Combustion	16	34	106
Industrial Materials for the Future	**31**	**74**	**207**
Sensors and Controls	1	9	37
Financial Assistance	82	157	404
Inventions & Innovations	61	112	283
NICE-3	21	45	121
Technical Assistance	48	209	496
Best Practices	35	169	438
Industrial Assessment Centers	14	40	58
OPT			
Biomass Power R&D	200	550	800
Competitive Solicitation	5	5	5
Distributed Energy Resources	300	400	550
Geothermal Energy R&D	85	400	650
High Temperature Superconductivity	5	100	350
Hydrogen	0	50	500
REPI	35	30	25
Solar Program	22	78	350
Concentrating Solar Power	2	13	100
Photovoltaic Systems R&D	5	20	100
Solar Buildings	15	45	150
Wind Energy R&D	**50**	**550**	**1,700**
OTT			
Biofuels	17	169	973
Materials Technologies	0	6	93
Vehicle Technologies	27	509	3,612
Advanced Combustion Engine R&D	**1**	**134**	**471**
Electric Vehicles R&D	15	34	142
Fuel Cell R&D	0	2	368
Heavy Vehicle Systems R&D	1	156	1,132
Hybrid Systems R&D	10	182	1,499
Fuel Utilization	0	0	0
Technology Deployment	0	0	0
FEMP	16	37	60

Bold = ADL reviewed program or subprogram