Appendix I – GPRA07 Federal Energy Management Program Documentation

Project Description. The mission of the Federal Energy Management Program (FEMP) is to promote energy security, environmental stewardship, and cost reduction through energy efficiency and water conservation; report progress toward the Executive Order goals at Federal sites; and support energy management activities of the Department of Energy.[1]

Through the Federal Government's own actions, FEMP's target is to facilitate energy efficiency and renewable energy investments in FY 2007 that will result in life-cycle energy savings of 17.1 trillion Btus. This target includes only those investments at Federal agencies that can be quantified and directly related to FEMP activities.[2]

FEMP's spreadsheet model is not integrated into the larger FY 2007 GPRA models (NEMS-GPRA07 and MARKAL-GPRA07). However, the delivered energy savings are used as inputs for the integrated modeling. The projected savings are subtracted from the Baseline Case for commercial-building energy consumption. Analysts use NEMS-GPRA07 to compute the other benefits metrics of primary energy savings, carbon emission reductions, and energy expenditure savings. This appendix provides an outline of how the delivered energy savings estimates were calculated. The specific mathematical calculations are available in two spreadsheet files which are available through the FEMP program.

Background: Note that the FY 2007 GPRA benefits were calculated during a transitional period in FEMP. In 2005, at the time the GPRA calculations had already been completed for the Corporate Review Budget, FEMP was in the midst of changing its metrics and benefits calculations as part of the OMB Program Assessment Rating Tool (PART) process. To ensure consistency between the GPRA benefits and the PART metrics, the final GPRA methodology for FY 2007 represents a somewhat disjointed approach, combining both a bottom-up approach to reflect PART and the existing GPRA top-down model. As part of the FY 2008 budget development process, FEMP will employ a more unified methodology to calculate GPRA benefits.

Target Market

Target Market Description. The target market is the Federal sector, the Nation's 3.0 billion square feet of standard Federal buildings (e.g., military bases, post offices, hospitals, courthouses) and the Nation's 300 million square feet of Federal energy-intensive operations (e.g., laboratories, check-processing facilities, and linear accelerators). The Federal Government's actions—via leadership, awards, influence, and raw purchasing power—may well influence private-sector and state and local government decisions with respect to energy-related decisions, but any such "spillover" impact is not estimated in this GPRA process.

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[1] Department of Energy FY 2007 Congressional Budget Request. Vol. 3. p. 407.
[2] Department of Energy FY 2007 Congressional Budget Request. Vol. 3. p. 408.

Key Factors in Shaping Market Adoption of EERE Technologies

Policy Factors. FEMP's mission is to assist the 32 Federal agencies in attaining the goals set by Executive Order and other legislation for the Federal government. Strictly speaking, these are not goals for FEMP but goals for each individual agency, and their involvement is essential. Executive Order 13123 establishes that the goal for all Federal agencies is to reduce energy intensity in "standard" Federal buildings by 35% by 2010 (relative to the 1985 statutory baseline level of 138,610 Btu per gross square foot).[3] Additionally, Executive Order 13123 contains a goal for energy-intensive operations, which is to reduce energy per square foot by 25% in 2010 relative to a 1990 baseline.

The Energy Policy Act of 2005 (EPACT 2005) establishes the following goals: to reduce energy consumption per square foot by 20% by 2015 compared to the baseline year of FY 2004 at a rate of 2% per year; and to ensure that at least 3% of Federal electricity consumption is generated by renewables in the years FY 2007 through FY 2009, by 5% in the years FY 2010 through FY 2012, and by 7.5% in FY 2013 and each fiscal year thereafter.[4]

Methodology and Calculations

FEMP used a combination of a "bottom-up" and "top-down" approach in calculating GPRA benefits that accrue due to its activities. For activities through FY 2010, FEMP estimated the energy savings that will result from only its quantifiable activities and then summed these savings to generate a comprehensive savings estimate. Quantifiable activities are limited to project financing projects, technical assistance projects, and departmental energy management projects.

Note that the comprehensive savings estimate does not take into account additional savings that likely result from FEMP's non-quantifiable activities (e.g., product specifications, outreach, training, reporting). Furthermore, the Federal Government's actions—via leadership, awards, influence, and raw purchasing power—may well influence private-sector and state and local government decisions with respect to energy-related decisions, but any such "spillover" impact is not estimated in this GPRA process.

For years FY 2011 through FY 2013, FEMP relied on a model and supporting research that estimates the government-wide energy savings for these years, and then approximated FEMP's contribution to this savings based on prior performance. Finally, for years 2014 and beyond, FEMP assumed a 1% annual decrease in the overall energy intensity of Federal facilities. Then, as with years FY 2011 through FY 2013, FEMP approximated its contribution to this reduction based on past performance.

Inputs to Base Case. FEMP did not provide inputs to change the Base Case assumptions for the program markets. FEMP's calculations were based on a baseline that was developed from Federal building historical energy-use data, per Executive Order and legislation.

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[3] Department of Energy FY 2007 Congressional Budget Request. Vol. 3. p. 409.
[4] Department of Energy FY 2007 Congressional Budget Request. Vol. 3. p. 409.

Technical Characteristics. FEMP maintains a database with information on all of the projects it assists—both through its technical assistance and project financing efforts. The database includes information regarding engineering estimates of energy and cost savings for individual projects among other important data. FEMP relied on this database, as well as written contracts, to develop annual energy savings estimates for projects it assisted in FY 2002, FY 2003, and FY 2004. These engineering estimates were used to develop a savings projection for FY 2007.

Annual energy savings projections attributable to quantifiable FEMP activities were calculated for five FEMP sub-programs using the following sources and assumptions. Life-cycle energy savings were estimated by multiplying the annual savings by 15 years, the average life span of installed energy-efficient equipment.

Project Financing Activities:

(1) Energy Savings Performance Contracts (ESPC)
    Annual savings for these contracts were obtained directly from FEMP Super ESPC Delivery Order schedules. Savings are assumed to begin accruing in the year of the delivery order award. In instances where annual savings were not available for a particular delivery order, the average savings per dollar of project investment (9,000 Btu/dollar) was used to estimate annual savings.

(2) Utility Energy Savings Contracts (UESC)
    These savings were obtained directly from UESCs awarded with direct assistance from FEMP.

(3) Energy Markets/Shared Energy Savings Support
    These estimates were derived from projects in which FEMP directly assisted Federal agencies in successfully applying for public benefit funds or other energy efficiency funds.

Technical Assistance Activities:

(4) Technical Assistance Projects (TA)
    These estimates reflect the savings potential from projects for which FEMP provided technical assistance, including both energy efficiency and renewable energy support. The estimates do not credit FEMP with the full energy savings potential by the projects, but rather for the incremental savings that would be accrued if FEMP's technical recommendations were followed. In the case of renewable energy projects, energy savings are presumed to equal the amount of energy generated from the on-site renewable project and used by the federal facility.

Departmental Energy Management Activities:

(5) Departmental Energy Management (DEMP)
    These estimates were derived directly from engineering estimates of energy savings reported by DOE sites that received funding from FEMP for energy efficiency and renewable energy projects.

FEMP Project Financing: Estimated Savings. FEMP Project Financing performance measures were derived from the average annual energy savings (in billion Btu) for projects signed in fiscal years 2002 through 2004. **Table I-1** details the annual FEMP-facilitated savings for the three project financing programs: Super ESPCs, Utility Energy Service Contracting support, and Energy Markets, including support for the United States Postal Service's shared energy savings projects.

Table I-1. Annual Savings (Billion Btu)

	2002	2003	2004	2002-2004
Super ESPC	517	2,634	215	3,366
UESC	204	163	140	507
Energy Markets	0	66	142	208
Project Financing Total	720	2,863	498	4,081

FEMP divided the average annual energy savings by the total project financing annual budgets (**Table I-2**) for the three years to determine "Annual Energy Savings per FEMP Dollar of Funding" shown in **Table I-3**.

Table I-2. Project Financing Dollars (Thousand $)

2002	2003	2004	2002-2004
$8,700	$7,839	$7,830	$24,369

Table I-3. Annual Energy Savings per FEMP Dollar of Funding (Site-Delivered Btu/$)

2002	2003	2004	2002-2004
82,813	365,224	63,550	167,469

The "Annual Energy Savings per FEMP Dollar of Funding" for 2002-2004 was multiplied by the approximate project financing budget request for FY 2007 ($6 million) to estimate annual savings from the project financing program for that year, yielding an estimate of 1,005 billion Btu.

FEMP's performance measure target for project financing in 2007 is 80% of the annual estimate for FY 2007 (or 804 billion Btu) based on the average performance of the fiscal years 2002 through 2004. FEMP used the 80% multiplier to ensure that the projected savings estimates were conservative and attainable.

FEMP calculated life-cycle energy savings by taking the estimated annual savings and multiplying by 15 to reflect an average project life of 15 years, for a total life-cycle energy savings of 12,060 billion site-delivered Btu.

FEMP Technical Assistance: Estimated Savings. Program performance measures for these activities were derived first from the estimated annual savings from all TA projects facilitated by FEMP (**Table I-4**) whether or not those projects are ultimately implemented by the agency. The estimated annual energy savings in million Btu (MMBtu) for fiscal years 2001 through 2004 were divided by the total TA budget for those years to arrive at "Identified Annual Savings from TA Projects per dollar of TA Funding" (200 MMBtu).

Table I-4. Technical Assistance Project Savings and Funding Levels

	2001	2002	2003	2004	2001 - 2004 4-Year Total	2007 Estimate
Total TA Funding (Thousand $)	$7,896	$7,000	$7,825	$8,140	$30,861	$6,591
Identified Savings from Recommended TA Projects (MMBtu)	824,019	865,590	3,695,862	776,670	6,162,141	1,316,052
Identified Savings per $ of TA funding (MMBtu)	104	124	472	95	200	200

FEMP multiplied the 200 MMBtu value (Identified Annual Savings per dollar of TA Funding) by the budget request for FY 2007 to estimate potential annual savings identified by all TA projects for FY 2007 (illustrated in the far right column of **Table I-4**).

FEMP estimated "Implemented Savings" for FY 2007 by taking 30% of estimated potential annual savings identified by all TA projects, yielding 395 billion Btu. FEMP used the 30% multiplier to reflect that not all projects for which FEMP provides technical assistance are actually implemented. Based on historical implementation rates, FEMP determined the 30% figure to be a reasonable estimate of how many projects would be implemented in the future.

FEMP calculated the target 2007 TA project target performance measure by taking 80% of estimated "Implemented Savings" from TA program facilitated projects yielding 316 billion Btu. FEMP used the 80% multiplier to ensure that the projected savings estimates were conservative and attainable.

FEMP calculated life-cycle energy savings by taking the estimated annual savings and multiplying by 15 to reflect an average project life of 15 years, for a total life-cycle energy savings of 4,740 billion site-delivered Btu.

FEMP Departmental Energy Management: Estimated Savings. FEMP DEMP performance measures were derived from the average annual energy savings (in billion Btu) for projects signed in fiscal years 2002 through 2004. **Table I-5** details the annual FEMP-facilitated savings, the DEMP budget, and the resulting "Annual Energy Savings per FEMP Dollar of Funding."

Table I-5. DEMP Annual Savings and Funding

	2002	2003	2004	2002-2004
Annual Savings (Billion Btu)	26.9	27.2	35.4	89.5
DEMP Budget (Thousand $)	$1,421	$1,445	$1,963	$4,829
DEMP Cost-Share from Sites (Thousand $)	$1,097	$402	$555	$2,054
Annual Energy Savings per Dollar of Funding (DEMP Budget plus Cost-Share)	10,683	14,727	14,059	13,003

The "Annual Energy Savings per FEMP Dollar of Funding" for 2002-2004 was multiplied by the approximate Departmental Energy Management budget request for FY 2007 ($2 million) to estimate annual savings from the Departmental Energy Management activities for that year, yielding an estimate of 26.0 billion Btu.

FEMP's performance measure target for DEMP in 2007 is 80% of the annual estimate for FY 2007 (or 20.8 billion Btu) based on the average performance of the fiscal years 2002 through 2004. FEMP used the 80% multiplier to ensure that the projected savings estimates were conservative and attainable.

FEMP calculated life-cycle energy savings by taking the estimated annual savings and multiplying by 15 to reflect an average project life of 15 years, for a total life-cycle energy savings of 312 billion site-delivered Btu.

Total estimated annual savings for all quantifiable FEMP activities for FY 2007 is 1.14 trillion Btu, which is equivalent to 17.1 trillion Btu life cycle energy savings. FEMP assumed that this target level of savings would remain in effect through 2010, based on the Executive Order goal year.

Projection of Estimated Savings through the Analysis Period. In order to project the estimated savings through the remainder of the analysis period (FY 2011 – FY 2030), FEMP developed an estimate of the reasonably attainable potential of the Federal sector. The method FEMP used to develop the Federal building retrofit potential is outlined in the next section on technical potential. Using this projection, FEMP calculated the amount of the total potential that is attributable to FEMP (based on FEMP's target), and applied that percentage to the projected estimates to obtain out-year FEMP savings. By using the projected Federal building retrofit potential, FEMP could incorporate future baseline changes in energy use intensity, which affect the level of savings.

FEMP used a weighted average for FY 2007 – FY 2010, equal to the sum of the target savings divided by the sum of the potential savings, as the attribution factor for FY 2011 through FY 2030. **Table I-6** provides the projected savings levels, the target levels, and the attribution percentage.

Table I-6. Development of Out-Year Energy Savings Estimates

Year	Potential Total Site Energy Displaced (TBtu)	FEMP Target, FY 2007 – FY 2010 (TBtu)	Attribution Factor
2007	6.68	1.14	17.08%
2008	13.22	2.28	17.25%
2009	19.63	3.42	17.43%
2010	25.91	4.56	17.60%
2015	50.45		17.42%
2020	65.73		17.42%
2025	80.26		17.42%
2030	94.07		17.42%

FEMP allocated the energy savings into savings by fuel type using historical fuel mix data from the Federal sector along with Energy Information Administration (EIA) forecasts, as outlined in the section, "Fuel Mix" within the Technical Potential section below. Energy savings by fuel type, measured in MMBtu, were converted to alternative units for reporting requirements via the conversion factors listed in **Table I-7**.

Table I-7. Energy Conversion Factors[5]

Fuel Oil: 5.825 MMBtu/barrel
Natural Gas: 1.027 MMBtu/1000 cubic feet
Coal: 22.489 MMBtu/short ton
Electricity: 3.412 MMBtu/MWh
LPG: 3.603 MMBtu/barrel

Energy Savings Results. Estimated annual and cumulative energy savings attributable to FEMP resulting from the FY 2007 Budget Request are summarized in **Table I-8** and **Table I-9**.

Table I-8. Annual Energy Metrics for Federal Standard Buildings and Energy-Intensive Operations (FY 2007 Budget Request)

Year	Total Site Energy Displaced (TBtu)	Direct Electricity Displaced (billion kWh)	Direct Natural Gas Displaced (billion CF)	Direct Petroleum Displaced (million barrels)	Direct Coal Displaced (million short tons)	Direct Biomass Displaced (TBtu)	Direct Energy Displaced from Feedstocks (TBtu)	Direct Energy Displaced from Wastes (TBtu)	Other Direct Energy Displaced (TBtu)
2007	1.140	0.114	0.426	0.014	0.009	0	0	0	0
2008	2.280	0.228	0.817	0.037	0.018	0	0	0	0
2009	3.420	0.345	1.240	0.055	0.027	0	0	0	0
2010	4.560	0.459	1.641	0.080	0.035	0	0	0	0
2015	8.790	0.816	3.378	0.181	0.061	0	0	0	0
2020	11.452	0.995	4.540	0.247	0.080	0	0	0	0
2025	13.984	1.183	5.605	0.311	0.098	0	0	0	0
2030	16.392	1.359	6.679	0.365	0.114	0	0	0	0

[5] Source: Performance Planning Guidance (GPRA Data Call) FY2004-2008 Budget Cycle-Draft. April 1, 2002. U.S. Department of Energy. Office of Energy Efficiency and Renewable Energy.

Table I-9. Cumulative Energy Metrics for Federal Standard Buildings and Energy-Intensive Operations (FY 2007 Budget Request)

Year	Total Site Energy Displaced (TBtu)	Direct Electricity Displaced (billion kWh)	Direct Natural Gas Displaced (billion CF)	Direct Petroleum Displaced (million barrels)	Direct Coal Displaced (million short tons)	Direct Biomass Displaced (TBtu)	Direct Energy Displaced from Feedstocks (TBtu)	Direct Energy Displaced from Wastes (TBtu)	Other Direct Energy Displaced (TBtu)
2007	1.140	0.114	0.426	0.014	0.009	0	0	0	0
2008	3.432	0.344	1.248	0.052	0.028	0	0	0	0
2009	6.886	0.692	2.501	0.108	0.055	0	0	0	0
2010	11.516	1.159	4.167	0.189	0.090	0	0	0	0
2015	47.779	4.633	17.724	0.920	0.346	0	0	0	0
2020	99.769	9.253	38.086	2.026	0.711	0	0	0	0
2025	164.676	14.785	64.058	3.453	1.165	0	0	0	0
2030	241.867	21.226	95.332	5.172	1.704	0	0	0	0

Technical Potential. FEMP estimated the energy savings to the Federal sector that FEMP expects to be reasonably attainable within the analysis period. FEMP estimated the Federal building retrofit potential as one combined effect in the market, measured in terms of energy use per square foot per year.

Actual historical and estimated future energy consumption are characterized in terms of fuel consumption (million Btu or MMBtu), fuel mix (the fractions of total fuel consumption by fuel type), and building floor space (thousand square feet or ksf). A critical derived figure is building energy intensity (MMBtu/ksf). The development of these measures is described in the sections that follow.

Historical Federal Agency Energy Consumption and Cost. Estimates of future Federal agency energy consumption start from the latest data available for actual energy consumption. For the analysis of impacts resulting from the FY 2007 Budget Request, the latest actual data were for FY 2004. These data were provided by the individual Federal agencies to McNeil Technologies, which has the responsibility for collecting and managing these data for FEMP. These data are eventually documented in the *Annual Report to Congress on Federal Government Energy Management and Conservation Programs*[6] for each fiscal year. As of September 2005, the most recent published version of this report covered fiscal year 2002 and was published September 29, 2004.

The historical data available for analysis are energy consumption (MMBtu) by fuel type and building floor space (ksf). These data are reported by each agency. The fuel type categories are electricity, fuel oil, natural gas, liquefied petroleum gas (lpg), coal, purchased steam, and "other." Building energy intensities (MMBtu/ksf) are calculated from these raw data.

Future Federal Agency Energy Consumption. Future Federal energy consumption was estimated by combining estimates of future building energy intensity, fuel mix, and building

[6] Available on FEMP's Web site at *http://www.eere.energy.gov/femp/pdfs/annrep02.pdf*

floor space. Total energy consumption (MMBtu) is the product of building energy intensity (MMBtu/ksf) and building floor space (ksf), as defined by Equation 1. Energy consumption by fuel type (MMBtu) is the product of total energy consumption and fuel-mix fraction for each fuel type, as defined by Equation 2.

$$E = EI_B \times SF_B \qquad \text{Eqn. 1.}$$

$$E_f = E \times F \qquad \text{Eqn. 2.}$$

Where E = total energy consumption (MMBtu)
EI_B = building energy intensity
SF_B = building floor space
E_f = energy consumption by fuel type
F = fuel mix fraction

The Department of Defense (DOD), DOE, General Services Administration (GSA), United States Postal Service (USPS), and Veterans Affairs (VA) were selected for specific metric development because they are the five largest agencies measured by annual energy use, consuming nearly 90% of the Federal total in FY 2004; DOD alone is nearly two-thirds of total Federal energy use (see **Figure I-1**). Reduction in MMBtu/ksf from FY 2003 through FY 2013 was estimated for each of these five agencies and all other agencies (27 total) grouped together for standard buildings. Metrics for energy intensive operations were developed for the Federal government as a whole. The following subsections describe the development of building energy intensity, building floor space, and fuel-mix fraction assumptions. In addition, the resulting estimates of building energy intensity reductions are provided.

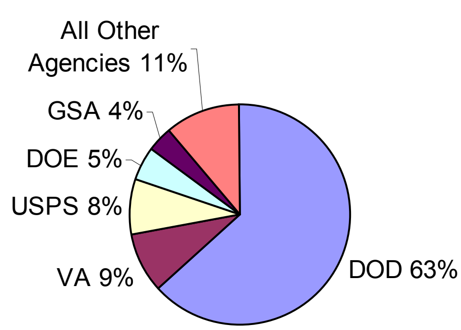

Figure I-1. FY 2004 Federal Agency Standard Building Energy Consumption

Building Energy Intensity. Estimates for agency-specific reductions in MMBtu/ksf by FY 2013 relative to FY 2003 were aggregated from estimates due to a) cost-effective retrofits of building energy systems, b) replacement of equipment upon failure (with generally more efficient equipment), c) cost-effective retrofits of central energy plants and thermal distribution systems (DOD, DOE, and VA only), and d) improvements in O&M practices. These four categories have differing assumptions, and the assumptions for each agency can be different within a particular category. The assumptions are discussed in the text below, and are based on literature referenced in the text. **Table I-10** presents the output estimates of energy intensity reductions derived from the spreadsheet model by category and agency.

Table I-10. Energy Intensity Reduction Estimates

Estimated Reduction in MMBtu/ksf by 2013 from 2003						
	Agency					
Reduction Source	**DOD**	**DOE**	**GSA**	**USPS**	**VA**	**Other**
Building Retrofit	5	8	6	6	6	6
Replace on Failure	4	10	3	3	7	5
CEP and Dist Retrofit	4	4			4	
Improved O&M	3	8	2	2	6	4
Total	16	30	11	11	23	15
FY 2003 MMBtu/ksf	102	238	69	68	186	124

The reduction in MMBtu/ksf from building retrofit was previously based on data developed in two Pacific Northwest National Laboratory (PNNL) reports, *Economic Energy Savings Potential in Federal Buildings,*[7] and *An Assessment of Prospective FORSCOM Energy Intensities.*[8] The former was prepared for FEMP by D. Brown, J. Dirks, and D. Hunt; the latter was prepared for the U.S. Army's Forces Command (FORSCOM) by D. Brown and J. Dirks.

The report for FEMP specifically examined the retrofit potential based on government financing for all government agencies, while the report for FORSCOM examined the retrofit potential for their facilities based on either government or alternative-financing (i.e., private funding) mechanisms.[9] The former report was used as the basis for civilian agencies while the latter was used for the military. The ratio of cost-effective savings found in the FORSCOM report for private and government funding was applied to the civilian results from the FEMP report to estimate civilian agency retrofit potential with private funding. Government-financed retrofit projects were assumed to be minimal, so the private funding potential was used for developing the energy intensity savings estimate. Finally, 50% of the potential was assumed captured over a 10-year period, from 2000 to 2010. This was consistent with the rate of annual alternative-financing investment and the ratio of energy savings per dollar invested from FY 1998 through FY 2000. The report for FORSCOM also looked at the impacts of the natural turnover of HVAC and service hot water (SHW) equipment (called "replace on failure" in **Table I-10**) and improvements to central energy plants (CEPs, i.e., boilers and/or chillers) and thermal-distribution systems.

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[7] D.R. Brown, J.A. Dirks, and D.M. Hunt. 2000. *Economic Energy Savings Potential in Federal Buildings*. PNNL-13332. Pacific Northwest National Laboratory. Richland, Washington.
[8] Distribution of the full report is limited by FORSCOM. The following paper, based on the full report, is publicly available. D.R. Brown and J.A. Dirks. 2002. "Prospective FORSCOM Energy Intensities." *Proceedings of the 25th World Energy Engineering Conference.* Association of Energy Engineers. Atlanta, Georgia.
[9] Alternative financing includes energy-saving performance contracts (ESPC) and utility energy service contracts (UESC).

Battelle, Pacific Northwest Division, and PNNL have since conducted approximately two dozen assessments of energy efficiency retrofit potential at Army facilities.[10] The Army facilities evaluated represent about 9% of total DOD floor space and have a mix of building types generally representative of DOD as a whole. The average retrofit potential via government funding was found to be 14.9 MMBtu/ksf, compared to 21.1 MMBtu/ksf in the prior FORSCOM study. The ratio of energy savings potential for private and government funding averaged 0.76, compared to 0.67 in the FORSCOM study.

The decline in cost-effective retrofit potential from the previous study is believed to be the result of the following three factors.

1. The recent Army results are based on a series of more thorough investigations than the previously cited work done specifically for FORSCOM.
2. Declining building energy intensities generally imply less energy savings potential, following the economic law of diminishing returns.
3. Privately financed projects in the past few years have dropped the Federal building energy intensity by about 3 MMBtu/ksf.

The increase in the ratio of private to government-financed cost-effective retrofit potential is consistent with a greater drop in private real interest rates compared to the government real interest rate. The latter has been limited by statute for the interest rate prescribed for energy projects by NIST to a minimum of 3% even though long-term Treasury bond rates and inflation forecasts suggest a lower real cost of government financing.[11]

Assuming that interest rates rise back toward long-run averages, the prescribed government rate will rise relatively little compared to the private rate. Thus, the cost-effective retrofit potential with government financing will remain the same while the cost-effective potential with private financing will drop. Therefore, the prior (0.67) ratio of private-funded to government-funded retrofit potential was thought to better represent the long-term condition.

The percentage decline in cost-effective retrofit potential collectively found in the more recent Battelle and PNNL studies for the Army was assumed to apply to the civilian agencies too because the latter two of the three explanatory factors cited above apply to both civilian and military agencies. The bottom line result was a 30% reduction in agency energy intensity via cost-effective building retrofits for the period 2004 through 2013 compared to the previous estimates developed for the period 2001 through 2010.

Replacement of HVAC and SHW equipment occurs continuously as equipment ages, fails, and must be replaced. In general, the efficiency of HVAC and SHW equipment has substantially improved because of technology advances, stimulated in part by stricter equipment and appliance standards at the national level. Other factors include building energy codes and the forces of technological innovation. As a result, replacement equipment will usually consume less energy than the equipment being replaced; and, in some cases, much less energy (refrigerators and

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[10] A complete listing of these references is presented at the end of this documentation.
[11] S.K. Fuller and A.S. Rushing. 2005. Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – April 2005. NISTIR 85-3273-20. National Institute of Standards and Technology. Gaithersburg, MD.

chillers, for example). The estimated energy-intensity reduction from this mechanism was about 4% over a 10-year period in the FORSCOM study; the estimated impact for civilian agencies was judged by FEMP to be the same, since the phenomenon of improving energy efficiency in new equipment and appliances is economy-wide and not restricted to just DOD. More specifically, the estimated impact was judged by FEMP to be similar on a percentage basis (proportional to current energy intensity) rather than similar on a fixed basis (the same MMBtu/ksf impact for all agencies). This latter assumption represents a change from prior year's estimate for this mechanism.

DOD sites often have large central energy plants (CEPs) and accompanying thermal distribution systems. Results from the recent PNNL studies conducted for the Army and cited above indicate a savings potential equivalent to about 8 MMBtu/ksf. Again, it is unlikely that 100% of the potential will be captured. A 50% capture fraction was assumed to be consistent with the building retrofit capture fraction assumption. Among the four civilian agencies considered explicitly, only DOE and VA have a significant number of sites with CEPs, so this projected savings was only applied to these two agencies, in addition to DOD. The estimated energy intensity reduction of 4 MMBtu/ksf is about 50% higher than the previous estimate. The increase can be attributed to consideration of decentralization from central boilers to building-level boilers (eliminating all thermal distribution losses external to a building) as well as improvements in the efficiencies of central boilers and existing thermal distribution systems.

The estimated decrease in MMBtu/ksf from improved O&M practices was previously developed from data presented in *Using Targeted Energy Efficiency Programs to Reduce Peak Electrical Demand and Address Electric System Reliability Problems* by S. Nadel (et al) of American Council for an Energy Efficient Economy (ACEEE); and *Energy and Comfort Benefits of Continuous Commissioning in Buildings* by D. Claridge (et al) of Texas A&M University. Specifically, Nadel estimated cost-effective energy savings via improved O&M practices to be between 5% and 15% of existing energy consumption, with a maximum penetration rate of 50%. A more recent PNNL study[12] conducted for FEMP also concluded that the energy savings potential through improved O&M practices is approximately 10% of existing energy consumption. The authors of the PNNL study agreed that capturing one-third of the O&M potential by 2013 relative to a 2003 baseline were reasonable assumptions. Previously, 25% of the estimated O&M savings potential was assumed captured by 2010 relative to 2000.

The FY 2013 building energy-intensity calculations are defined by Equation 3 for standard buildings. To calculate energy intensity for FY 2013, the estimated reductions in MMBtu/ksf shown in **Table I-10** are subtracted from the actual energy intensities for each agency in FY 2003. Although actual FY 2004 energy consumption data are currently available, the estimated energy intensities for FY 2013 are based on FY 2003 to be consistent with the references (reports for FEMP and the Army described above) supporting the figures in **Table I-10**. As described earlier, the FY 2010 energy intensity for energy-intensive operations was set at the value that exactly meets the energy-intensity goal for these types of facilities.

[12] W.D. Hunt and G.P. Sullivan. 2002. *Assessing the Potential for a FEMP Operations and Maintenance (O&M) Program to Improve Energy Efficiency*. PNNL-14076. Pacific Northwest National Laboratory. Richland, Washington.

$$EI_B \text{ in FY 2013} = EI_B \text{ in FY 2003} - EI_B \text{ Reduction Estimate} \qquad \text{Eqn. 3}$$

Where EI_B = building energy intensity

Energy intensities for years between FY 2004 and FY 2013 were geometrically interpolated between these two endpoints. Energy intensities beyond FY 2013 were assumed to continue declining, with each year 1% less than the previous year. This is a conservative assumption compared to the average compounded rate of decline from 1985 through 2004, which was 1.5%.

Building Floor Space. As Federal floor space is not specifically tracked nor projected by EIA, future Federal building floor space was set equal to the FY 2004 value, i.e. no change in floor space was assumed through FY 2030. Total Federal floor space has been relatively constant since FY 1997 after declining from FY 1985 to FY 1997. The decline through FY 1997 was driven mostly by reductions in DOD. Continued decline in DOD floor space since FY 1997 has been offset by increases in other agencies. Most notably, USPS floor space has increased by 85% from FY 1985 through FY 2004. It is not clear whether an increase or decrease in floor space is more likely during the next 5 years, let alone the next 25 years; therefore, floor space was assumed to remain constant for the duration of the analysis period.

Fuel Mix. Since FY 1985, total site use of coal and fuel oil has declined significantly, while the use of electricity has remained nearly constant and the use of natural gas has declined slightly. As a consequence of these changes, the fractions of fuel use associated with electricity (and to a lesser extent, natural gas) have increased over time (See **Figure I-2**). EIA forecasts from the *Annual Energy Outlook 2005* suggest that this trend will continue, with site use of electricity increasing relative to other energy forms.

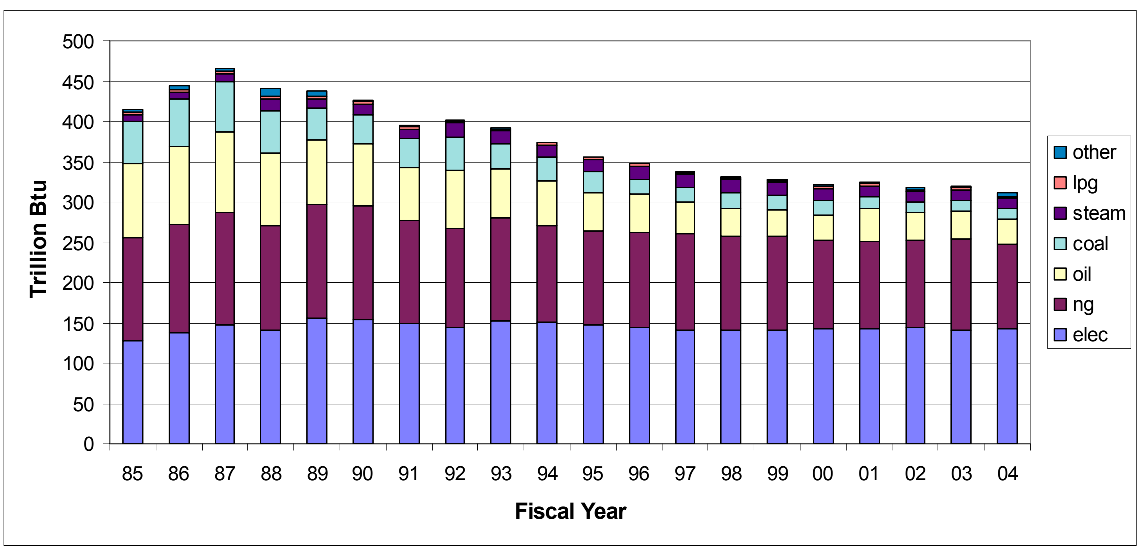

Figure I-2. Historical Energy Use in Standard Federal Buildings

Changes in the forecast fuel mix for the commercial sector from EIA's *Annual Energy Outlook 2005* were applied to the actual Federal fuel mixes in FY 2004 to estimate future federal fuel mixes. Projected changes for the commercial-sector fuel mix were first normalized relative to the existing commercial-sector fuel mix in 2004. For example, the normalized electricity fraction in the commercial sector grew from 1.0 (by definition) in 2004 to 1.17 in 2030. In contrast, the normalized natural gas fraction in the commercial sector fell from 1.0 in 2004 to 0.84 in 2030. The normalized fuel fractions for each fuel and each year were multiplied by the actual Federal fuel fractions in 2004 for each agency or agency group to estimate future Federal fuel mixes.

This procedure was applied to standard buildings, but not to energy-intensive operations. There, it was not so clear what sector (commercial or industrial) would better represent energy-intensive operations or whether the year-to-year volatility in reported data for energy-intensive operations would invalidate the refined approach. Instead, future fuel mixes for energy-intensive operations were assumed to remain as they were in FY 2004.

Federal Agency Energy Consumption Baseline. The estimated FY 2006 Federal agency energy consumption is used as the baseline Federal agency energy consumption. FY 2007 is the first possible year that could be affected by the FY 2007 budget, so FY 2006 is the logical baseline year. As previously described, the latest actual data are from FY 2004. Energy consumption by fuel type is estimated for each year after FY 2004, including the FY 2006 baseline year, via the process described above in the section on Future Federal Agency Energy Consumption.

Future Federal Agency Energy Savings. Annual energy savings were calculated by subtracting the estimated energy consumption in FY 2006 from the estimated energy consumption for FY 2007 and each following year. These calculations were done for each fuel type. Implicitly, if not for activities conducted by FEMP and the Federal agencies, future energy consumption would remain as estimated for FY 2006, and there would be no energy savings. Energy savings were summed across agencies and fuel types to determine total energy savings. Equations 4 through 6 define these calculations.

$$ES_{f,A} \text{ in FY20XX} = E_{f,A} \text{ in FY20XX} - E_{f,A} \text{ in FY2006} \qquad \text{Eqn. 4.}$$

$$ES_{f,F} \text{ in FY20XX} = \Sigma\, ES_{f,A} \text{ in FY20XX} \qquad \text{Eqn. 5.}$$

$$ES_{F} \text{ in FY20XX} = \Sigma\, ES_{f,F} \text{ in FY20XX} \qquad \text{Eqn. 6.}$$

Where $ES_{f,A}$ = energy savings by fuel type and agency
$E_{f,A}$ = energy consumption by fuel type and agency
$ES_{f,F}$ = Federal energy savings by fuel type
ES_{F} = Federal energy savings

The estimated Federal building retrofit potential energy savings are contained in **Table I-6**, in the column titled "Potential Total Site Energy Displaced."

Sources for Building Energy Retrofit Potential

Battelle, Pacific Northwest Division Reports

Brown, D.R., J.A. Dirks, D.L. Hadley, B. Liu, and S.A. Parker. 2004. *Final Assessment Report for Fort Shafter, Hawaii: Western Power Grid Peak Demand and Energy Reduction Program*. PNWD-3412. Battelle—Pacific Northwest Division, Richland, WA.

Brown, D.R., J.A. Dirks, D.L. Hadley, B. Liu, and S.A. Parker. 2004. *Final Assessment Report for Schofield Barracks, Hawaii: Western Power Grid Peak Demand and Energy Reduction Program*. PNWD-3413. Battelle—Pacific Northwest Division, Richland, WA.

Brown, D.R., J.A. Dirks, D.L. Hadley, B. Liu, A.P. Melendez, E.E. Richman, and S.A. Parker. 2003. *Final Assessment Report for Fort Huachuca, Arizona: Western Power Grid Peak Demand and Energy Reduction Program*. PNWD-3411. Battelle—Pacific Northwest Division, Richland, WA.

Dahowski, R.T., D.R. Dixon, D.L. Smith, and S.A. Parker. 2004. *Final Assessment Report for Fort Drum, New York: Western Power Grid Peak Demand and Energy Reduction Program*. PNWD-3368. Battelle—Pacific Northwest Division, Richland, WA.

Hadley, D.L., D.R. Dixon, A.E. Solana, and S.A. Parker. 2004. *Final Assessment Report for Fort Carson, Colorado: Western Power Grid Peak Demand and Energy Reduction Program*. PNWD-3410. Battelle—Pacific Northwest Division, Richland, WA.

Hadley, D.L., B. Liu, J.A. Dirks, and S. A. Parker. 2004. *Final Assessment Report for the Presidio of Monterey, California: Western Power Grid Peak Demand and Energy Reduction Program*. PNWD-3414. Battelle—Pacific Northwest Division, Richland, WA.

Parker, G.B., D.L. Hadley, D.L. Smith, A.E. Solana, and S.A. Parker. 2004. *Final Assessment Report for Sierra Army Depot, California: Western Power Grid Peak Demand and Energy Reduction Program*. PNWD-3417. Battelle—Pacific Northwest Division, Richland, WA.

Parker, G.B., B. Liu, E.E. Richman, A.P. Melendez, and S.A. Parker. 2004. *Final Assessment Report for Parks Reserve Forces Training Area (RFTA), California: Western Power Grid Peak Demand and Energy Reduction Program*. PNWD-3416. Battelle—Pacific Northwest Division, Richland, WA.

Pacific Northwest National Laboratory Reports

Brown, D.R., J.A. Dirks, D.R. Dixon, and G. B. Parker. 2003. *Southeast Region 10-Year Energy Plans; Prospective Energy Savings; Hunter Army Airfield.*_ PNNL-14607. Pacific Northwest National Laboratory. Richland, Washington.

Brown, D.R., J.A. Dirks, D.R. Dixon, and G. B. Parker. 2003. *Southeast Region 10-Year Energy Plans; Prospective Energy Savings; Fort Stewart.* PNNL-14608. Pacific Northwest National Laboratory. Richland, Washington.

Brown, D.R., and J.A. Dirks. 2003. *Southeast Region 10-Year Energy Plans; Prospective Energy Savings; Fort McPherson.* PNNL-14606. Pacific Northwest National Laboratory. Richland, Washington.

Brown, D.R., and J.A. Dirks. 2003. *Southeast Region 10-Year Energy Plans; Prospective Energy Savings; Fort Gillem.* PNNL-14605. Pacific Northwest National Laboratory. Richland, Washington.

Brown D.R., J.A. Dirks, and R.W. Reilly. 2004. *FORSCOM 10-year Energy Plans - Prospective Energy Savings at Fort Campbell* . PNNL-14598. Pacific Northwest National Laboratory, Richland, WA.

Brown, D.R., J.A. Dirks, and D.R. Dixon. 2005. *Facility Energy Decision System (FEDS) Assessment Report for Anniston Army Depot, Alabama*. PNNL-15216. Pacific Northwest National Laboratory. Richland, WA.

Brown, D.R., J.A. Dirks, and D.R. Dixon. 2005. *Facility Energy Decision System (FEDS) Assessment Report for Fort Bragg, North Carolina*. PNNL-15100. Pacific Northwest National Laboratory. Richland, WA.

Chvala, W.D., B. Liu, D.R. Brown, and D.R. Dixon. 2004. *Facility Energy Decision System (FEDS) Assessment Report for Fort Benning, Georgia*. PNNL-14885. Pacific Northwest National Laboratory. Richland, WA.

Chvala, W.D., A.E. Solana, and D.R. Dixon. 2005. *Facility Energy Decision System (FEDS) Assessment Report for Fort Buchanan, Puerto Rico*. PNNL-15053. Pacific Northwest National Laboratory. Richland, WA.

Chvala, W.D., D.R. Brown, and D.R. Dixon. 2004. *Facility Energy Decision System (FEDS) Assessment Report for Redstone Arsenal, Alabama*. PNNL-14905. Pacific Northwest National Laboratory. Richland, WA.

Hadley, D.L., B. Liu, W.D. Chvala, A.E. Solana, and D.R. Dixon. 2004. *Facility Energy Decision System (FEDS) Assessment Report for Fort Knox, Kentucky.* PNNL-14827. Pacific Northwest National Laboratory. Richland, WA.

Liu, B., G.P. Sullivan, G.B. Parker, E.E. Richman, A.E. Solana, and D.R. Dixon. 2005. Facility Energy Decision System (FEDS) Assessment Report for Military Ocean Terminal (MOT) Sunny Point, North Carolina. PNNL-15090. Pacific Northwest National Laboratory. Richland, WA.

Parker, G.B., A.E. Solana, D.L. Hadley, and D.R. Dixon. 2004. Facility Energy Decision System (FEDS) Assessment Report for Fort Jackson, South Carolina. PNNL-14781. Pacific Northwest National Laboratory. Richland, WA.

Parker, G.B., A.E. Solana, and D.R. Dixon. 2005. Facility Energy Decision System (FEDS) Assessment Report for Blue Grass Army Depot, Kentucky. PNNL-15075. Pacific Northwest National Laboratory. Richland, WA.

Sullivan, G.P., A.E. Solana, E.E. Richman, and D.R. Dixon. 2005. Facility Energy Decision System (FEDS) Assessment Report for Fort Gordon, Georgia. PNNL-15068. Pacific Northwest National Laboratory. Richland, WA.