Appendix E – GPRA06 Federal Energy Management Program Documentation

Introduction

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, the use of distributed and renewable energy, and sound utility management decisions at Federal sites. [FY 2005 Congressional Budget Request, p. 475]

The Federal Energy Management Program goal is to provide technical and financial assistance to Federal agencies and thereby lead the Nation by example in use of energy efficiency and renewable energy. Through the Federal Government's own actions, FEMP's target is to increase Federal renewable energy use to 2.5% of total Federal electrical energy use by 2005, and reduce energy intensity in Federal buildings by 30% by 2005 (relative to the 1985 statutory baseline level of 138,610 Btu per gross square foot). By 2010, the target is to further reduce energy intensity in Federal buildings by 35% (relative to the 1985 statutory baseline level).[FY 2005 CBR, p. 476] Resource assumptions for FEMP are shown in **Table 1**.

Table 1. Resource Assumptions for FEMP, FY 2005 to FY 2010.
(in millions of nominal dollars)

FY05	FY06	FY07	FY08	FY09	FY10
18.4	17.1	17.1	17.1	17.1	17.1

Introduction to GPRA Metrics Approach

Pacific Northwest National Laboratory (PNNL) calculates the potential site energy impacts of FEMP's portfolio for DOE/EERE. The details of those mathematical calculations are available for review in an annotated Excel spreadsheet, which provides a transparent "A to Z" understanding of how the year 2010 impacts are estimated. Individuals interested in the specific details should refer to that file, available from PNNL by contacting Daryl Brown (daryl.brown@pnl.gov). FEMP's detailed spreadsheet model is not integrated into the larger FY 2006 GPRA models (NEMS-GPRA06 and MARKAL-GPRA06). However, to provide source energy savings, energy-expenditure savings, and carbon emission reductions attributed to FEMP, the outputs of the spreadsheet model are fed into the larger GPRA models exogenously and the larger models report these benefits.

A detailed narrative description of the approach, and a summary of the results, follows below in the section Energy Savings Calculation Mechanics. The purpose of this introductory section is to provide a general understanding of the approach and assumptions at a higher level.

There are four key principles governing PNNL's estimation of GPRA metrics for FEMP.

First, the principal goal examined for metrics development is the 2010 site energy-intensity goal for "standard" buildings and facilities described above. PNNL also estimates the impact of the Executive Order 13123 goal for energy-intensive operations, which is to reduce energy per square foot by 25% in 2010, relative to a 1990 baseline. Both of these goals are stated in terms of energy use, per year, per square foot of floor space. It is important to note that FEMP's mission is to assist the 31 Federal agencies in attaining these executive order goals for the Federal government. Strictly speaking, these are not goals for FEMP but goals for each individual agency, and their involvement is essential. As noted above, the Federal sector also has a renewables goal for FY05, but FEMP's role in helping Federal agencies meet this goal was not estimated by PNNL because any impact through FY05 would not be affected by the FY 2006 budget request.

Second, to estimate impacts in the Federal marketplace, PNNL treats the entire Federal Energy Management Program as one unified deployment program. That is, PNNL takes what is often called a "top-down" approach to calculate 2010 energy impacts. The impact of FEMP's broad portfolio of deployment activities – alternative financing, direct technical assistance, training and information, publication of the Annual Report to Congress, procurement recommendations – is estimated as one combined effect in the market, measured in terms of energy use per square foot per year. Put differently, separate impacts for each FEMP activity are *not* estimated and then summed; the approach is not "bottom-up".

Third, the target market is the Federal sector, the Nation's 3.0 billion square feet of federal buildings space – military bases, post offices, VA hospitals, Department of Energy (DOE) laboratories, courthouses – and the Nation's Federal energy intensive operations. (Energy-intensive operations include, for example, 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.

Finally, the question of attribution of impact must be addressed. The mission of FEMP is to assist the Department of Defense, GSA, and other Federal agencies in attaining legislative and executive order energy goals for those agencies. The analysis needs to determine how much of that goal achievement is attributable to FEMP. Very specifically, how much of the site energy-intensity reduction in Federal buildings and facilities, from FY 2006 to FY 2010, is attributable to the portfolio of FEMP activities funded between FY 2006 and FY 2010, assuming level funding? In the GPRA analysis, PNNL assumes that 50% of the progress is attributable to FEMP's leadership and to FEMP's diverse portfolio. The other 50% is attributable to conservation retrofit funding, awareness campaigns at other Federal agencies, as well as to the existence of appliance and equipment standards and general technological innovation.

The 50% estimate was originally derived from analysis performed in support of the Energy Savings Performance Contract alternative financing activity within FEMP.[1] An assessment of the likely agency markets for alternative-financing products from FEMP (both ESPC and Utility

[1] FEMP Fiscal Year 1999 ESPC Business Strategy Development Summary Report, K. McMordie-Stoughton and D. Hunt, Pacific Northwest National Laboratory, March 2000, PNNL-13204.

Programs) produced estimates of FEMP programmatic impact of 35% to 55%, with most of the remainder being attributed to the Army Corps' Huntsville ESPC operation. This estimate did *not* include the likely impacts of the rest of FEMP's portfolio – direct technical assistance, training, and information. Taking the lower-end estimate of 35% and including these other impacts, PNNL estimated that a reasonable impact was 50%.

Energy Savings Calculation Mechanics

Actual historical and estimated future energy consumption are characterized in terms of fuel consumption (MMBtu or million Btu), fuel mix (the fractions of total fuel consumption by fuel type), and building floor space (ksf or thousand square feet). 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 2006 Budget Request, the latest actual data were for FY 2003. These data were provided by the individual Federal agencies to McNeil Technologies, which has the responsibility for collecting and managing these data for FEMP. In turn, PNNL receives these data from McNeil. These data are eventually documented in the *Annual Report to Congress on Federal Government Energy Management and Conservation Programs*[2] for each fiscal year. As of January 2005, the most recent published version of this report covered fiscal year 2001 and was published February 4, 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 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.

Total Energy = Building Energy Intensity * Building floor space Eqn. 1.

Fuel Type "A" Energy = Total Energy * Fuel "A" Mix Fraction Eqn. 2.

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 FY2003; DOD alone is nearly two-thirds of total

[2] Available on FEMP's Web site at http://www.eere.energy.gov/femp/about/annual_report.cfm

Federal energy use (see **Figure 1**). Reduction in MMBtu/ksf from FY2000 through FY2010 was estimated for each of these five agencies and all other agencies (24 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.

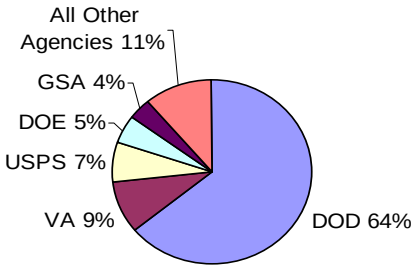

Figure 1. FY 2003 Federal Agency Standard Building Energy Consumption

Building Energy Intensity

Estimates for agency-specific reductions in MMBtu/ksf by FY2010 relative to FY2000 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), d) construction of new housing (DOD only), and e) improvements in O&M practices. These five 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 2** presents the output estimates of energy intensity reductions derived from the spreadsheet model by category and agency.

Table 2. Energy-Intensity Reduction Estimates

Estimated Reduction in MMBtu/ksf by 2010 from 2000						
	Agency					
Reduction Source	**DOD**	**DOE**	**GSA**	**USPS**	**VA**	**Other**
Building Retrofit	7	11	9	8	8	9
Replace on Failure	4	4	4	4	4	4
CEP and Dist Retrofit	2.5	2.5			2.5	
Improved O&M	3	6	2	2	4	3
New Housing	0.5					
Total	17	23.5	15	14	18.5	16
FY2000 MMBtu/ksf	105	249	67	74	168	115

The reduction in MMBtu/ksf for Federal agencies was based primarily on data developed in two PNNL reports, *Economic Energy Savings Potential in Federal Buildings*[3], and *An Assessment of Prospective FORSCOM Energy Intensities*[4]. The former was prepared for FEMP by D. Brown, J. Dirks, and D. Hunt and is available from PNNL's Web site at http://www.pnl.gov/main/publications/; 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 mechanisms[5]. 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 2**), improvements to central energy plants (CEPs, i.e., boilers and/or chillers) and thermal distribution systems, and housing privatization plans (demolition, renovation, and new construction).

FORSCOM facilities represent about 10% of total DOD floor space and have a mix of buildings types generally representative of DOD as a whole. In addition, the retrofit-estimating methodology was more robust than that used for the DOD sector in the FEMP report. Therefore, the FORSCOM results were used as the basis for estimating retrofit potential for DOD, while the FEMP results were used as the basis for other agencies.

The estimated retrofit potential for non-DOD agencies from the FEMP report was reduced by one-third to reflect alternative financing rather than government financing (appropriations). This factor is driven by the higher interest rates and shorter financing periods typically seen for alternative financing and is based on work by J. Dirks, D. Brown, and J. Currie of PNNL[6]. Finally, 50% of the estimated potential via alternative financing was assumed captured by FY2010. This will approximately occur if the rate of annual alternative-financing investment from FY1998 through FY2000 continues through FY2010, with the same ratio of energy savings per dollar invested as seen in FY1998 through FY2000.

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 chillers, for example). The estimated energy-intensity reduction from this mechanism was about 4 MMBtu/ksf in the FORSCOM study; the estimated impact for civilian agencies was judged by

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[3] 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.

[4] 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.

[5] Alternative financing includes energy-saving performance contracts (ESPC) and utility energy service contracts (UESC).

[6] J.A. Dirks, D.R. Brown, and J.W. Currie. 1999. Sensitivity of ESPC Projects to Changes in Interest Rates and Energy Prices. Pacific Northwest National Laboratory. Richland, Washington. An informal letter report from PNNL to FEMP.

PNNL 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.

DOD sites often have large CEPs and accompanying thermal distribution systems. Results from the FORSCOM report indicated potential energy savings equivalent to a reduction in building energy intensity of 5 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 decrease in MMBtu/ksf from improved O&M practices was 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%. To be conservative, PNNL used a penetration rate of 25% for the FEMP GPRA analysis. Thus, starting from an average potential of 10%, the estimated savings from improved O&M practices was set equal to 2.5% of energy consumption in FY2000.

DOD is unique among the Federal agencies with respect to the housing stock it manages for military personnel and their families. About 90% of federal housing stock, or about 600 million square feet, resides in the military. All three branches of the military are currently privatizing a significant portion of their housing stock. Privatization plans, besides transferring ownership, call for significant demolition, new construction, and renovation. The impact of these housing-stock changes was estimated (in the FORSCOM report) to reduce FORSCOM's overall building energy intensity by about 3 MMBtu/ksf. This figure was reduced to 0.5 MMBtu/ksf for DOD, as a whole, because the energy impacts of housing privatization are concentrated within FORSCOM.

The FY2010 building energy-intensity calculations are defined by Equation 3 for standard buildings. To calculate energy intensity for FY2010, the estimated reductions in MMBtu/ksf shown in **Table 2** are subtracted from the actual energy intensities for each agency in FY2000. Although actual FY2003 energy consumption data are now available, the estimated energy intensities for FY2010 are based on FY2000 to be consistent with the references (reports for FEMP and FORSCOM described above) supporting the figures in **Table 2**. As described earlier, the FY2010 energy intensity for energy-intensive operations was set at the value that exactly meets the energy-intensity goal for these types of facilities.

Building Energy Intensity in FY2010 =
Building Energy Intensity in FY2000 –
Building Energy Intensity Reduction Estimate Eqn. 3

Energy intensities for years between FY2003 and FY2010 were geometrically interpolated between these two endpoints. Energy intensities beyond FY2010 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 2003, which was 1.5%.

Building Floor Space

Future building floor space was set equal to the FY2003 value, i.e. no change in floor space was assumed through FY2030. Note, however, that floor space has been increasing slowly since FY1997 at a rate of about 0.4% per year, after declining from FY1985 to FY1997. The decline through FY1997 was driven mostly by reductions in DOD, while the increase since FY1997 is mostly attributable to USPS. It is not clear whether an increase or decrease in floor space is more likely during the next 10 years, let alone the next 30 years; therefore, floor space was assumed to remain constant for the duration of the analysis period.

Fuel Mix

Since FY1985, 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 2**). EIA forecasts from the *Annual Energy Outlook 2004* suggest that this trend will continue, with site use of electricity increasing relative to other energy forms.

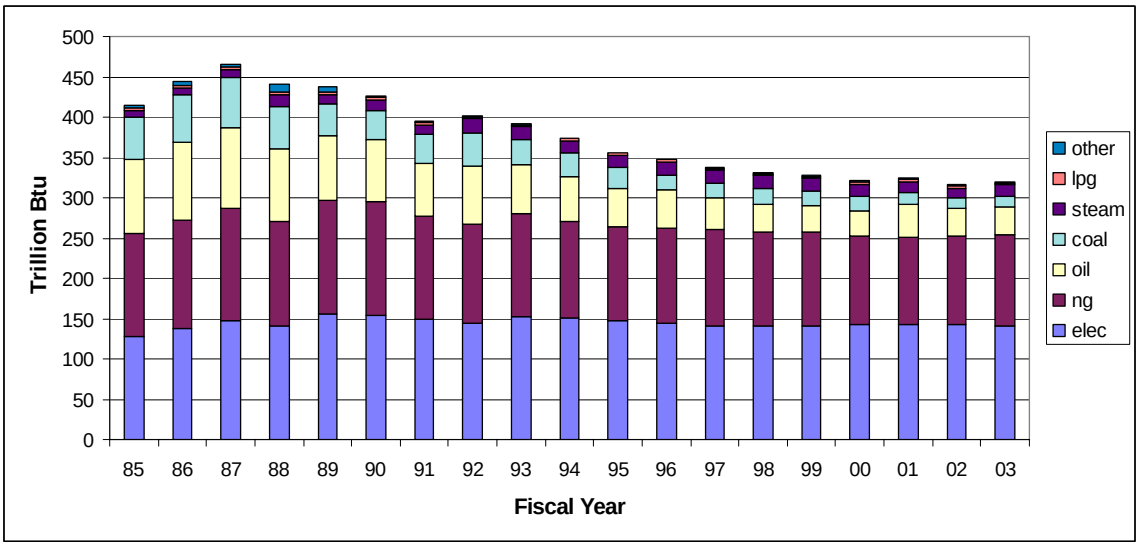

Figure 2. Historical Energy Use in Standard Federal Buildings

Changes in the forecast fuel mix for the commercial sector from EIA's *Annual Energy Outlook 2004* were applied to the actual Federal fuel mixes in FY2003 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 2003. For example, the normalized electricity fraction in the commercial sector grew from 1.0 (by definition) in 2003 to 1.18 in 2030. In contrast, the normalized natural gas fraction in the commercial sector fell from 1.0 in 2003 to 0.86 in 2030. The normalized fuel fractions for each fuel and each year were multiplied by the actual Federal fuel fractions in 2003 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 FY2003.

Federal Agency Energy Consumption Baseline

The baseline Federal agency energy consumption is the estimated Federal agency energy consumption in FY2005. FY2006 is the first possible year that could be affected by the FY2006 budget, so FY2005 is the logical baseline year. As previously described, the latest actual data are from FY2003. Energy consumption by fuel type is estimated for each year after FY2003, including the FY2005 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 FY2005 from the estimated energy consumption for FY2006 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 FY2005, and there would be no energy savings. Energy savings were summed across agencies and fuel types to determine total energy savings. Equations 4-6 define these calculations.

Fuel Type A Energy Savings for Agency B in FY20XX =
Fuel Type A Energy Consumption for Agency B in FY20XX –
Fuel Type A Energy Consumption for Agency B in FY2005 Eqn. 4.

Fuel Type A Federal Energy Savings in FY20XX=
Σ Fuel Type A Energy Savings across all Agencies in FY20XX Eqn. 5.

Federal Energy Savings in FY20XX =
Σ Fuel Type A Federal Energy Savings across all Fuel Types Eqn. 6.

Energy savings by fuel type, measured in MMBtu, were converted to alternative units for reporting requirements via the conversion factors listed in **Table 3**.

Table 3. Energy Conversion Factors[7]

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

[7] 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.

Energy Savings Results

Estimated annual and cumulative energy savings attributable to FEMP resulting from the FY 2006 Budget Request are summarized in **Table 4** and **Table 5**.

Table 4. Annual Energy Metrics for Federal Standard Buildings and Energy-Intensive Operations (FY 2006 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)
2006	4.07	0.453	1.37	0.112	0.0218	0	0	0	0
2007	8.04	0.849	2.82	0.204	0.0479	0	0	0	0
2008	11.91	1.217	4.29	0.301	0.0711	0	0	0	0
2009	15.70	1.612	5.61	0.398	0.0939	0	0	0	0
2010	19.40	2.013	6.88	0.489	0.1154	0	0	0	0
2015	27.42	2.409	10.78	0.726	0.1705	0	0	0	0
2020	35.05	2.975	13.80	0.973	0.2204	0	0	0	0
2025	42.30	3.612	16.59	1.181	0.2636	0	0	0	0
2030	49.19	4.089	19.63	1.376	0.3067	0	0	0	0

Table 5. Cumulative Energy Metrics for Federal Standard Buildings and Energy-Intensive Operations (FY 2006 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)
2006	4.07	0.45	1.4	0.11	0.022	0	0	0	0
2007	12.10	1.30	4.2	0.32	0.070	0	0	0	0
2008	24.02	2.52	8.5	0.62	0.141	0	0	0	0
2009	39.72	4.13	14.1	1.02	0.235	0	0	0	0
2010	59.12	6.14	21.0	1.50	0.350	0	0	0	0
2015	180.34	17.40	67.0	4.70	1.095	0	0	0	0
2020	340.47	31.12	130.2	9.05	2.097	0	0	0	0
2025	537.60	47.87	207.9	14.53	3.329	0	0	0	0
2030	769.91	67.35	300.1	21.03	4.778	0	0	0	0