APPENDIX B

Calculation Methodologies

This appendix provides methodologies for calculating the metrics requested in the GPRA2003 Data Call. The general framework for the methodology is depicted in the Figure B-1 below. Additional details are provided in the sections that follow.

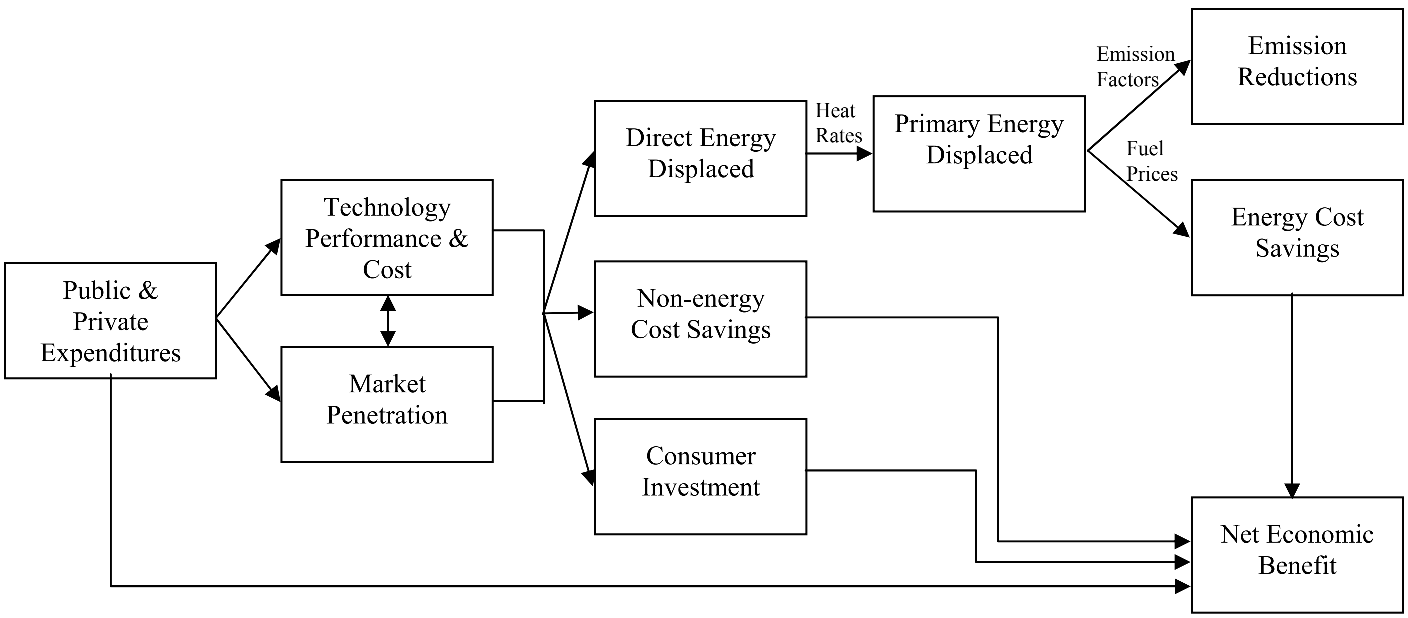


Figure B-1: EERE GPRA2003 Calculation methodology framework

Calculating Public & Private Expenditures

Programs should identify annual and cumulative expenditures by EERE, other government agencies, and the private sector.

Calculating Public & Private Expenditures – An Example

An EERE program is funding R&D for an advanced technology that will reduce natural gas and electricity consumption in an industrial process. The EERE program has provided $5 million in funding through 2002 and plans to provide additional funding from 2003 through 2007. No other government funding is being provided, but the private sector is matching EERE's funding (and continues through 2009). The first step is to identify the stream of historical and projected annual expenditures.

Annual Expenditures
(Millions nominal $)

Step (1)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
EERE	1.000	1.000	1.000	1.000	1.000	1.000	2.000	2.000	1.000	1.000
Other Government	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Private Sector	1.000	1.000	1.000	1.000	1.000	1.000	2.000	2.000	1.000	1.000

The second step is to apply the GDP implicit price deflators from Appendix C of the data call.

GDP Implicit Price Deflators
(1999 = 1.000)

Step (2)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Price Deflator	0.985	1.000	1.022	1.044	1.064	1.087	1.111	1.135	1.158	1.180

This results in annual expenditures in 1999 dollars. Expenditures before 2003 will be included in cumulative expenditures (see below). Expenditures from 2003-2007 will be reported under annual expenditures. These become the basis of revision after the budget is received.

Annual Expenditures
(Millions 1999 $)

Step (3)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
EERE	1.015	1.000	0.978	0.958	0.940	0.920	1.800	1.762	0.863	0.847
Other Government	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Private Sector	1.015	1.000	0.978	0.958	0.940	0.920	1.800	1.762	0.863	0.847

The fourth step is to identify cumulative expenditures. This is done by adding annual expenditures to cumulative expenditures for the previous year.

Cumulative Expenditures
(Millions 1999 $)

Step (4)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
EERE	5.810	7.610	9.372	10.235	11.082	11.082	11.082	11.082	11.082	11.082
Other Government	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Private Sector	5.810	7.610	9.372	10.235	11.082	12.730	12.730	12.730	12.730	12.730

Identifying Technology Performance and Cost

Technology performance and cost information should be provided for the advanced EERE technology and the baseline technology. The baseline technology should represent the **next best alternative** to the advanced EERE technology. It should not represent the average technology in the market or the technology being replaced. As a general rule, programs should use the technology characteristics contained in EIA's Annual Energy Outlook 2001 (AEO2001) as the baseline. In instances where the AEO2001 does not contain baseline information, programs should draw such information from other credible sources.

Identifying Technology Performance and Cost – An Example

An EERE program is funding R&D for an advanced technology that will reduce natural gas and electricity consumption in an industrial process. The EERE-funded R&D is expected to accelerate the market introduction of the technology from 2014 to 2009.

Step 1 consists of identifying the relevant performance parameters for 1) the advanced technology with EERE involvement, 2) the advanced technology without EERE involvement, and 3) the next best alternative. The annual energy consumption of the process using the next best alternative technology is 400 million ft^3 of natural gas and 20 million kWh of electricity in 2000. These levels are expected to decline by 0.20% per year. The annual energy consumption with the advanced technology is expected to be 360 million ft^3 of natural gas and 18 million kWh of electricity per year, levels estimated to improve by 0.15% per year through 2030 (see Figure B-2 and the table below).

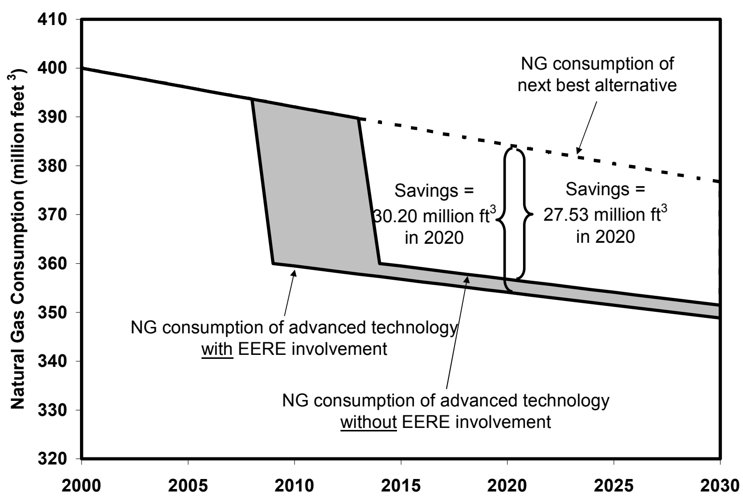


Figure B-2: Unit energy consumption of advanced EERE technology and next best alternative

Unit Energy Consumption

Step (1)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Natural Gas (million ft^3)										
Adv. Tech. With EERE	---	---	---	---	---	359.46	356.77	354.10	351.46	348.83
Adv. Tech. Without EERE	---	---	---	---	---	---	359.46	356.77	354.10	351.46
Next Best Alternative	397.60	396.81	396.02	395.22	394.43	392.07	388.17	384.30	380.47	376.68
Electricity (million kWh)										
Adv. Tech With EERE	---	---	---	---	---	17.97	17.84	17.71	17.57	17.44
Adv. Tech. Without EERE	---	---	---	---	---	---	17.97	17.84	17.71	17.57
Next Best Alternative	19.88	19.84	19.80	19.76	19.72	19.60	19.41	19.22	19.02	18.83

In step 2 the unit energy savings of the advanced technology are calculated relative to the next best alternative. The energy savings of the advanced technology with EERE involvement is about 30.20 million ft^3 of natural gas and 1.51 million kWh of electricity per year in 2020. The energy savings of the advanced technology without EERE involvement is about 27.53 million ft^3 of natural gas and 1.38 million kWh of electricity per year in 2020.

Unit Energy Savings

Step (2)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Natural Gas (million ft^3)										
Adv. Tech With EERE	---	---	---	---	---	32.61	31.39	30.20	29.02	27.85
Adv. Tech Without EERE	---	---	---	---	---	---	28.71	27.53	26.37	25.23
Electricity (million kWh)										
Adv. Tech With EERE	---	---	---	---	---	1.63	1.57	1.51	1.45	1.39
Adv. Tech Without EERE	---	---	---	---	---	---	1.44	1.38	1.32	1.26

Step 3 identifies the capital costs for each technology. These are shown in the table below and in Figure B-3.

**Capital Cost
(Millions 1999 $)**

Step (3)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	6.50	6.03	5.59	5.18	4.81
Adv. Tech. Without EERE	---	---	---	---	---	---	6.50	6.03	5.59	5.18
Next Best Alternative	5.82	5.76	5.71	5.65	5.59	5.43	5.16	4.91	4.67	4.44

In step 4 the incremental capital costs of the advanced technology are calculated relative to the next best alternative.

**Incremental Capital Cost
(Millions 1999 $)**

Step (4)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	1.07	0.87	0.68	0.52	0.37
Adv. Tech. Without EERE	---	---	---	---	---	---	1.34	1.12	0.92	0.74

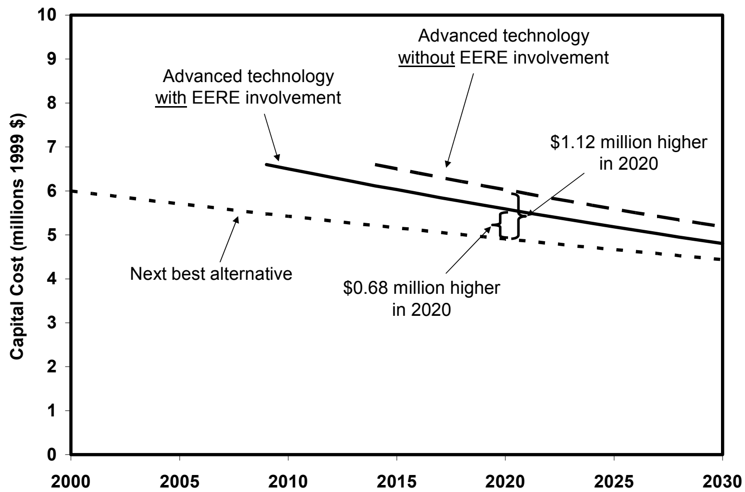


Figure B-3: Capital costs of advanced EERE technology and next best alternative

Step 5 calculates annualized capital cost by dividing capital cost by the lifetime of the technology.

Annualized Capital Cost
(Millions 1999 $/year)

Step (5)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	0.65	0.60	0.56	0.52	0.48
Adv. Tech. Without EERE	---	---	---	---	---	---	0.65	0.60	0.56	0.52
Next Best Alternative	0.58	0.58	0.57	0.57	0.56	0.54	0.52	0.49	0.47	0.44

Step 6 calculates the incremental annualized capital costs of the advanced technology relative to the next best alternative.

Incremental Annualized Capital Cost
(Millions 1999 $/year)

Step (6)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	0.11	0.09	0.07	0.05	0.04
Adv. Tech. Without EERE	---	---	---	---	---	---	0.13	0.11	0.09	0.07

Step 7 identifies the O&M costs for each technology.

O&M Costs
(Millions 1999 $)

Step (7)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	0.0650	0.0603	0.0559	0.0518	0.0481
Adv. Tech. Without EERE	---	---	---	---	---	---	0.0650	0.0603	0.0559	0.0518
Next Best Alternative	0.0582	0.0576	0.0571	0.0565	0.0559	0.0543	0.0516	0.0491	0.0467	0.0444

Step 8 calculates the incremental O&M costs of the advanced technology relative to the next best alternative.

Incremental O&M Costs
(Millions 1999 $)

Step (8)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	0.0107	0.0087	0.0068	0.0052	0.0037
Adv. Tech. Without EERE	---	---	---	---	---	---	0.0134	0.0112	0.0092	0.0074

Identifying Market Penetration Information

Market penetration levels should be identified for the advanced EERE technology and the baseline technology. As a general rule, programs should use the market penetration levels contained in EIA's Annual Energy Outlook 2001 (AEO2001) as the baseline. In instances where the AEO2001 does not contain baseline information, programs should draw such information from other credible sources.

The market penetration information for the advanced EERE technology should include a commercialization year and major milestones leading to commercialization. In identifying a commercialization year, programs should consider that it usually takes several years to move from research and development to the introduction of a product into the marketplace. The timeframe in Figure B-4 (ADL, 2000) should serve as a guide.

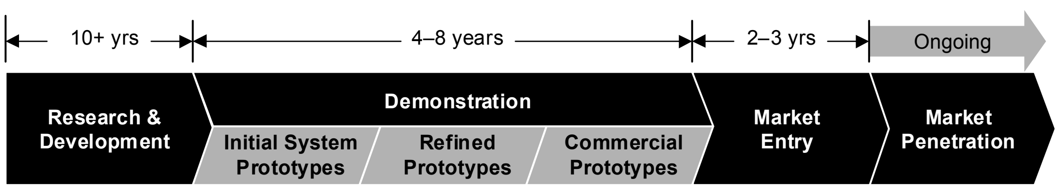


Figure B-4. The Technology Development Process

Identifying Market Penetration – An Example

Step 1 identifies the commercialization year and the major milestones leading to commercialization. In this example, major milestones include an initial prototype in 2002, a refined prototype in 2004, and a commercial prototype in 2007, with commercialization in 2009.

Step (1)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Initial Prototype	X									
Refined Prototype			X							
Commercial Prototype						X				
Commercialization								X		

Step 2 identifies the market penetration levels of the advanced technology with and without EERE involvement resulting in the net penetration of the advanced technology. In this example, the market penetration curve of the advanced technology with EERE involvement is the same as market penetration curve without EERE involvement, except that it is shifted to the left by five years.[1] The net market penetration is the difference between the two curves, or the shaded area in Figure B-5. The total market size in both cases is 500 units.

With EERE involvement, 32 units were added in 2020, for a cumulative total of 106. Without EERE involvement, 5 units would have been added in 2020, for a cumulative total of 14. Thus, the net number of installations added in 2020 was 27 for a net cumulative total of 92 units. Cumulative and annual market penetration levels are shown in the tables below.

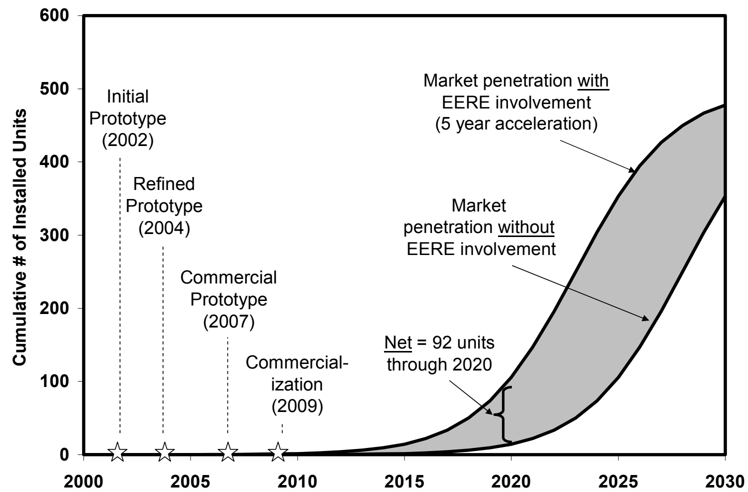


Figure B-5: Major milestones and cumulative market penetration for advanced EERE technology

Market Penetration
(# units)

Step (2)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Penetration										
Adv. Tech. With EERE	---	---	---	---	---	2	14	106	353	478
Adv. Tech. Without EERE	---	---	---	---	---	---	2	14	106	353
Annual Penetration										
Adv. Tech. With EERE	---	---	---	---	---	1	5	32	49	11
Adv. Tech. Without EERE	---	---	---	---	---	---	1	5	32	49

[1] The market penetration curve, measured in percentage of market captured, is shifted to the left by five years. In this example, zero market growth is assumed over the market penetration period. Thus, the market penetration curve, measured in absolute numbers (# units), is the same. If market growth or decline is projected, then the two curves, measured in absolute numbers, will differ.

Calculating Direct Energy Displaced

The amount of direct energy displaced is a function of per unit energy displacement and the number of units in the market. Direct energy displaced may be measured in a number of ways. The *incremental direct energy displaced* is the amount of energy displaced for the number of units installed in a year. The *annual direct energy displaced* represents the amount of energy displaced in a year for the units installed thus far. It is the summation of incremental energy benefits over the years of interest

Calculating Direct Energy Displaced – An Example

This example continues from above. In Step 1 the amount of incremental direct energy displaced is calculated. The incremental energy benefit of the 32 units installed in 2020 is a combination of three calculations. First, there are 966 million ft^3 of natural gas savings from the advanced technology with EERE involvement (32 units x 30.20 million ft^3/unit). Second, these savings are reduced by the 138 million ft^3 of natural gas for units that would have been installed without EERE involvement (5 units x 27.53 million ft^3/unit). Third, there are further reductions of 1 million ft^3 in natural gas due to increased consumption of stock turnover (the per unit savings is less than it was ten years earlier – the lifetime of the advanced technology). Thus, the amount of incremental energy displaced for the 32 installed in 2020 would be about 827 million ft^3 of natural gas. Similar calculations for electricity show 0.04 billion kWh of electricity displaced.

Incremental Direct Energy Displaced

Step (1)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Direct Electricity Displaced (billion kWhs)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.03	-0.05
Direct Natural Gas Displaced (billion cubic feet)	0.00	0.00	0.00	0.00	0.00	0.02	0.14	0.83	0.57	-0.99

Step 2 calculates the amount of annual direct energy displaced. When the incremental benefits are summed for all 106 units penetrating the market through 2020 and replacements accounted for, the annual direct energy displaced in 2020 is about 2.8 billion ft^3 of natural gas and 0.14 billion kWh of electricity. Projections for 2003-2030 are provided in the table below. Figure B-6 shows the amount of natural gas displaced annually.

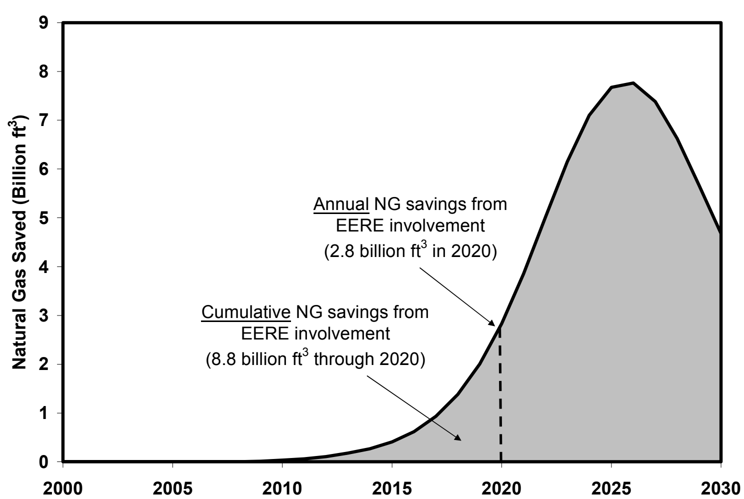


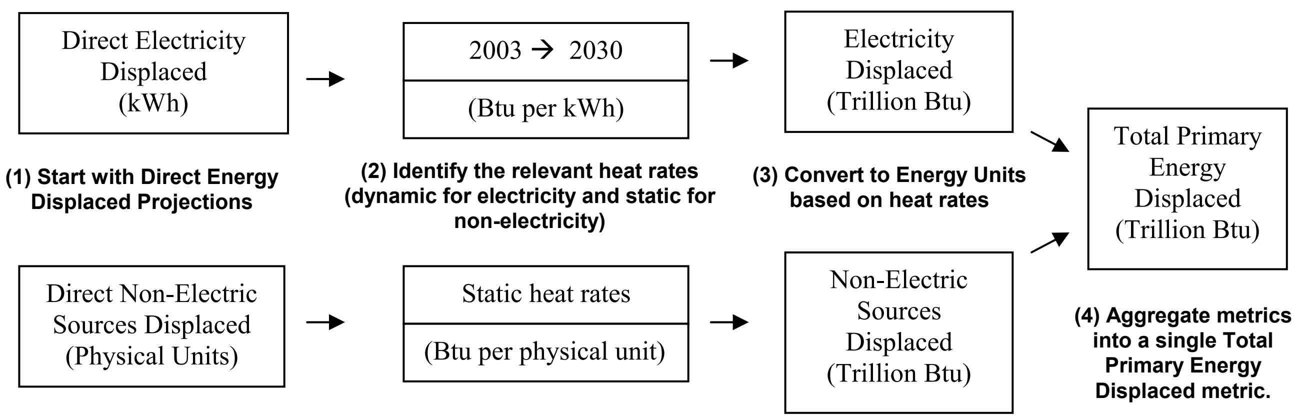
Figure B-6. Natural gas displaced from technology with 5-year accelerated market introduction

Annual Direct Energy Displaced

Step (2)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Direct Electricity Displaced (billion kWhs)	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14	0.38	0.23
Direct Natural Gas Displaced (billion cubic feet)	0.00	0.00	0.00	0.00	0.00	0.03	0.41	2.83	7.67	4.68

Converting from Direct to Primary Energy Displaced

The process for converting projections of direct energy displaced into a single total primary energy displaced metric involves four steps. These steps are displayed in the diagram below.



(1) The first step in the conversion process is to identify the electric and non-electric displaced energy projections. The direct electricity displaced projections will be expressed in kilowatt-hours; the direct non-electric projections will be expressed in barrels of oil, cubic feet of natural gas, and short tons of coal.

(2) The next step involves the conversion from direct units into heat content units using the heat rate of each direct fuel source.

Electricity Heat Rates

Electricity heat rates for GPRA2003 were derived by comparing the AEO2001 reference case against a side case in which electricity demand was reduced. The first step was to determine the marginal fuel mix based on the differences in kWh of electricity generated. The results, shown in the table below, indicate that EERE technologies are projected to displace electricity generated from fossil fuels.

Projected Marginal Fuel Generation Mix
(based on marginal kWh generated)

Fuel	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Coal	24.3%	27.8%	35.9%	39.7%	47.7%	46.9%	38.5%	35.0%	35.0%	35.0%
Natural Gas	64.5%	62.9%	58.8%	54.9%	47.7%	51.9%	60.3%	63.2%	63.2%	63.2%
Oil	11.3%	9.2%	5.3%	5.4%	4.7%	1.2%	1.3%	1.8%	1.8%	1.8%

The second step was to calculate the marginal electricity heat rates for each fuel source based on a comparison of the two cases. The results are shown in the table below.

Projected Marginal Electricity Heat Rates by Fuel Source

Projected Electricity Heat Rates	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Coal (Btu per kWh)	10,724	10,616	10,601	10,583	10,556	10,387	10,402	9,942	9,942	9,942
Natural Gas (Btu per kWh)	10,858	10,787	10,573	9,736	9,624	7,754	6,866	6,705	6,705	6,705
Oil (Btu per kWh)	10,599	10,494	10,767	10,724	10,354	10,354	10,043	9,658	9,658	9,658

To derive the dynamic GPRA2003 electricity heat rates, the percentage of the marginal mix associated with each fuel source was multiplied by the expected electricity heat rate for the same source. This yielded the intermediate apportioned heat content associated with each generation source. Then, for each forecast year, the apportioned heat contents were summed to arrive at a final GPRA2003 heat rate. For example, in the year 2020, electricity generated from coal is expected to account for 35.0 percent of the marginal mix, electricity generated from natural gas 63.2 percent, and oil 1.8 percent. The expected electricity heat rates in 2020 for coal, natural gas and oil are 9,942 and 6,705 and 9,658 Btu/kWh, respectively. Therefore, the GPRA2003 heat rate for 2020 is (35.0%)(9,942) + (63.2%)(6,705) + (1.8%)(9,658) = 7,891 Btu/kWh.

GPRA2003 Electricity Heat Rates

GPRA2003 Heat Rate	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (Btu per kWh)	10,796	10,713	10,593	10,126	10,102	9,019	8,266	7,891	7,891	7,891

Non-Electric Heat Rates

The heat rates used for conversion of non-electric sources are much more straightforward. The table below contains the appropriate conversion factors for these sources that are based on heat rate estimates provided in AEO2001 Table H1. Simply find the matching direct energy displaced source with the appropriate heat rate from the table below.

GPRA2003 Non-Electricity Heat Rates

Coal			
	Coal Production	million Btu per short ton	21.224
	Coal Consumption	million Btu per short ton	20.760
	Coke Plants	million Btu per short ton	26.800
	Industrial	million Btu per short ton	22.104
	Residential and Commercial	million Btu per short ton	22.783
	Electric Utilities	million Btu per short ton	20.479
	Coal Coke	million Btu per short ton	24.800
Oil			
	Crude Oil Production	million Btu per barrel	5.800
	Oil Products Consumption	million Btu per barrel	5.360
	Motor Gasoline	million Btu per barrel	5.234
	Jet Fuel (Kerosene)	million Btu per barrel	5.670
	Distillate Fuel Oil	million Btu per barrel	5.825
	Residual Fuel Oil	million Btu per barrel	6.287
	Liquefied Petroleum Gas	million Btu per barrel	3.625
	Kerosene	million Btu per barrel	5.670
	Petrochemical Feedstocks	million Btu per barrel	5.630
	Unfinished Oils	million Btu per barrel	5.825
Natural Gas			
	Natural Gas Production	Btu per cubic foot	1,026
	Natural Gas Consumption	Btu per cubic foot	1,026
	Non-electric Utilities	Btu per cubic foot	1,027
	Electric Utilities	Btu per cubic foot	1,019

Source: AEO2001, Table H1.

(3) The third step involves multiplying the above heat rates by the direct energy displaced projections.

(4) The final step is to sum the energy displaced estimates (not expressed in heat content units) for each forecast year.

Converting from Direct to Primary Energy – An Example

To better understand the mechanics of the energy conversion process, consider the following example, which continues from the amount of annual direct energy displaced calculated above.

Step (1)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Direct Electricity Displaced (billion kWhs)	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14	0.38	0.23
Direct Natural Gas Displaced (billion cubic feet)	0.00	0.00	0.00	0.00	0.00	0.03	0.41	2.83	7.67	4.68

In step 2, the relevant heat rates are identified. A static conversion factor is used for the non-electric projections while a dynamic heat rate is used for electricity.

Step (2)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (Btu per kWh)	10796	10713	10593	10126	10102	9019	8266	7891	7891	7891
Natural Gas Consumption (Btu per cubic foot)	1026	1026	1026	1026	1026	1026	1026	1026	1026	1026

In step 3, all direct energy displaced estimates are converted from physical units to heat content units by multiplying by the appropriate heat rates.

Step (3)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.01	0.17	1.12	3.03	1.84
Natural Gas (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.03	0.42	2.90	7.87	4.80

Step 4 simply involves summing the metrics in each forecast year to arrive at projections of *annual primary energy displaced*.

Step (4)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Annual Primary Energy Displaced (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.05	0.59	4.02	10.90	6.64

Step 5 involves calculating the *cumulative primary energy displaced*. This is simply a summation of annual energy benefits over the years of interest.

Step (5)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Primary Energy Displaced (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.07	1.55	12.68	54.99	100.60

Step 6 calculates the *lifecycle primary energy displaced.* This is a summation of the annual energy displaced over the lifetime of the technologies installed through that year.

Step (6)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Lifecycle Primary Energy Displaced (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.46	5.89	40.80	114.94	107.22

Calculating Emissions Displaced

The methodology for calculating the level of emissions displaced continues from the conversion of direct to primary energy displaced. Emission factors are applied to the projections of primary energy displaced by energy source to obtain emissions displaced by energy source. These estimates are then summed to arrive at a final estimate of emissions displaced.

The GPRA2003 Data Call uses carbon emission factors found in Table 2 of the Assumptions to the AEO2001. These emission factors are based on the carbon content of the fuel and the fraction of the fuel consumed in combustion. The emission factors are based on 1999 data.

Adjusted Carbon Emission Factors (1999)
(Million Metric Tons of Carbon per Trillion Btu)

	Fuel	Emission Factor
Petroleum		
	Motor Gasoline	0.01917
	LPG	
	Used as Fuel	0.01709
	Used as Feedstock	0.00338
	Jet Fuel	0.01914
	Distillate Fuel	0.01975
	Residual Fuel	0.02128
	Asphalt and Road Oil	0.00000
	Lubricants	0.01214
	Petrochemical Feedstocks	0.00387
	Kerosene	0.01952
	Petroleum Coke	0.01393
	Petroleum Still Gas	0.01742
	Other Industrial	0.02011
Coal		
	Residential and Commercial	0.02574
	Metallurgical	0.02530
	Industrial Other	0.02538
	Electric Utility	0.02550
Natural Gas		
	Used as Fuel	0.01440
	Used as Feedstocks	0.01120

Like the electricity heat rate, the carbon emission factor for electricity changes over the forecast period with the changing projections of the marginal fuel mix. The petroleum mix for the utility sector is 95% residual fuel and 5% distillate fuel.

Electricity Carbon Emission Factor
(million metric tons of carbon per trillion Btu)

Carbon Coefficient	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (MMTCE per trillion Btu)	0.01783	0.01808	0.01875	0.01939	0.02025	0.02048	0.01988	0.01944	0.01944	0.01944

The Environmental Protection Agency catalogues criteria pollutant emission factors for numerous technologies. For the GPRA Data Call more generic emission factors have been calculated from aggregate emission and energy consumption data provided by EPA for 1997. These are provided in the tables below. Emission factors for specific technologies may be obtained from EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) available on the world wide web at http://www.epa.gov/ttn/chief/ap42etc.html

Emission Factors of Criteria Pollutants
(Metric tonnes of emissions per trillion Btu)

Fuel	NOx	SO2	VOCs	CO	PM10
Coal	254	568	1	11	12
Natural Gas	106	0	3	29	0
Oil	140	527	4	13	7

Like the electricity carbon emission factor, the electricity criteria pollutant emission factors are dynamic, changing over time with the changing fuel mix.

Electricity Emission Factors of Criteria Pollutants
(Metric tonnes of emissions per trillion Btu)

Criteria Pollutant	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
NOx	146	150	161	170	182	187	178	172	172	172
SO2	196	205	233	266	308	314	283	262	262	262
VOCs	3	3	2	2	2	2	2	2	2	2
CO	23	23	22	21	19	19	20	21	21	21
PM10	4	4	5	5	6	7	6	6	6	6

Calculating Emissions Displaced – An Example

To better understand how to calculate emissions displaced, consider the following example for carbon. The example continues from primary energy displaced in the example above.

Step (1)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.01	0.17	1.12	3.03	1.84
Natural Gas (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.03	0.42	2.90	7.87	4.80

Instead of summing these metrics to arrive at annual primary energy displaced, the appropriate carbon emissions coefficients are applied.

Step (2)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (MMTCE per trillion Btu)	0.01783	0.01808	0.01875	0.01939	0.02025	0.02048	0.01988	0.01944	0.01944	0.01944
Natural Gas (MMTCE per trillion Btu)	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440	0.01440

The resultant emissions displaced projections are listed in the table below.

Step (3)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (MMTCE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.04
Natural Gas (MMTCE)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.11	0.07

The next step is to sum these individual estimates to arrive at annual carbon equivalent emissions displaced as illustrated below.

Step (4)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Annual Carbon Equivalent Emissions Displaced (MMTons)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	0.17	0.10

The next step is to sum these individual estimates to arrive at cumulative carbon equivalent emissions displaced as illustrated below.

Step (5)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Carbon Equivalent Emissions Displaced (MMTons)	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.20	0.87	1.59

The cumulative life cycle carbon emissions displaced are also calculated.

Step (6)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Life Cycle Carbon Equivalent Emissions Displaced (MMTons)	0.00	0.00	0.00	0.00	0.00	0.01	0.09	0.65	1.82	1.70

Calculating Energy Cost Savings

The methodology for calculating energy cost savings differs slightly for electricity and non-electricity energy sources. For non-electricity energy sources, sector energy prices are applied to the projections of primary energy displaced by energy source to obtain energy cost savings by energy source. For electricity, the amount of direct electricity displaced in kWh is converted to site electricity in trillion btu and then multiplied by the sector electricity price. Electricity and non-electricity cost savings estimates are then summed to arrive at total energy cost savings. The GPRA2003 Data Call uses energy prices in Table 20 of the Assumptions to the AEO2001 (found in Appendix C of the data call).

Calculating Energy Cost Savings – An Example

To better understand how to calculate energy cost savings, consider the following example. The process starts with the estimates of direct energy displaced.

Step (1)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Direct Electricity Displaced (billion kWhs)	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14	0.38	0.23
Direct Natural Gas Displaced (billion cubic feet)	0.00	0.00	0.00	0.00	0.00	0.03	0.41	2.83	7.67	4.68

Heat rates are applied to the estimates. Note that an electricity *consumption* heat rate is used.

Step (2)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity Consumption (Btu per kWh)	3412	3412	3412	3412	3412	3412	3412	3412	3412	3412
Natural Gas Consumption (Btu per cubic foot)	1026	1026	1026	1026	1026	1026	1026	1026	1026	1026

This results in the heat content for each energy source.

Step (3)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Site Electricity (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.48	1.31	0.80
Natural Gas (trillion Btu)	0.00	0.00	0.00	0.00	0.00	0.03	0.42	2.90	7.87	4.80

Appropriate energy prices are applied (industrial sector prices are used here).

Step (4)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (1999 $ per million Btu)	12.94	12.83	12.34	12.03	11.61	11.24	11.27	11.62	11.82	12.02
Natural Gas (1999 $ per million Btu)	3.24	3.14	3.17	3.20	3.24	3.31	3.45	3.76	4.01	4.28

Resulting in energy cost savings projections for each fuel.

Step (5)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Electricity (million 1999 $)	0	0	0	0	0	0	1	6	15	10
Natural Gas (million 1999 $)	0	0	0	0	0	0	1	11	32	21

Individual fuel savings estimates are summed to arrive at annual energy cost savings.

Step (6)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Annual Energy Cost Savings (million 1999 $)	0	0	0	0	0	0	2	17	47	30

The annual savings are summed to arrive at an estimate of cumulative energy cost savings.

Step (7)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Energy Cost Savings (million 1999 $)	0	0	0	0	0	0	6	50	230	432

Cumulative life cycle energy cost savings are then calculated.

Step (8)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Life Cycle Energy Cost Savings (million 1999 $)	0	0	0	0	0	2	23	171	497	462

Calculating Non-Energy Cost Savings

In certain instances an advanced EERE technology will result in cost savings beyond those derived from decreased energy consumption. For instance, some technologies may result in productivity gains to industry. To the extent possible, programs should identify and estimate these non-energy cost savings.

Calculating Non-Energy Cost Savings – An Example

The advanced EERE technology in the above example results in less down-time for an industrial process. As a result, an additional $250,000 in goods are produced annually for each unit that is installed. The productivity savings are estimated to remain constant for the foreseeable future. Per unit productivity savings are applied to the market penetration levels identified above to arrive at annual non-energy cost savings.

Step (1)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Annual Non-Energy Cost Savings (million 1999 $)	0	0	0	0	0	0	3	23	62	31

The annual figures are summed to arrive at a cumulative estimate of non-energy cost savings.

Step (2)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Non-Energy Cost Savings (million 1999 $)	0	0	0	0	0	0	8	70	312	553

Cumulative life cycle non-energy cost savings are then calculated

Step (3)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Life Cycle Non-Energy Cost Savings (million 1999 $)	0	0	0	0	0	2	32	230	651	542

Calculating Consumer Investment

Technology cost and market penetration information should be used to calculate the consumer investment in the advanced EERE technology.

Calculating Consumer Investment – An Example

In the first step the incremental annualized capital costs and incremental O&M costs are taken from the example above.

Incremental Annualized Capital Costs
(Millions 1999 $)

Step (1a)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	0.11	0.09	0.07	0.05	0.04
Adv. Tech. Without EERE	---	---	---	---	---	---	0.13	0.11	0.09	0.07

Incremental O&M Costs
(Millions 1999 $)

Step (1b)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	0.0107	0.0087	0.0068	0.0052	0.0037
Adv. Tech. Without EERE	---	---	---	---	---	---	0.0134	0.0112	0.0092	0.0074

Annual market penetration estimates are also taken from the example above.

Annual Market Penetration
(# units)

Step (2)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Adv. Tech. With EERE	---	---	---	---	---	1	5	32	49	11
Adv. Tech. Without EERE	---	---	---	---	---	---	1	5	32	49

The incremental annualized capital and O&M costs are then multiplied by the annual number of units installed to arrive at incremental consumer investment. For instance, the incremental capital investment for the 32 units added in 2020 would be about $1.6 million. This is a combination of three calculations. First, there is $2.2 million in investment for the 32 units relative to the next best alternative (32 units x $0.07 million/unit). Second, there is $0.6 million less invested because 5 of the units would have been installed without EERE involvement (5 units x $0.11 million/unit). Third, there is also a negligible reduction for stock being turned over at a lower cost (1 unit x $0.04 million). The $1.6 million represents additional capital investment consumers will need to make in 2020 (assuming capital costs are annualized). Finally, there are $0.2 million in additional O&M costs associated with the 32 new technologies.

The incremental capital and O&M investments are then summed to arrive at $1.8 million in incremental consumer investment. The incremental consumer investment is positive in 2030 because the market penetration curve of the advanced technology with EERE involvement is slowing down relative to the market penetration of the advanced technology without EERE involvement.

Incremental Consumer Investment

Step (3)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Incremental Capital Investment (Millions 1999 $)	0	0	0	0	0	0	0	-2	-1	4
Incremental O&M Investment (Millions 1999 $)	0	0	0	0	0	0	0	0	0	0
Incremental Consumer Investment (Millions 1999 $)	0	0	0	0	0	0	0	-2	-1	4

Annual consumer investment is the summation of incremental consumer investment.

Annual Consumer Investment

Step (4)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Annual Capital Investment (Millions 1999 $)	0	0	0	0	0	0	-1	-6	-11	6
Annual O&M Investment (Millions 1999 $)	0	0	0	0	0	0	0	-1	-1	1
Annual Consumer Investment (Millions 1999 $)	0	0	0	0	0	0	-1	-7	-12	6

Cumulative consumer investment is simply a summation of incremental consumer investment to date.

Cumulative Consumer Investment

Step (5)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Capital Investment (Millions 1999 $)	0	0	0	0	0	0	-3	-21	-74	-85
Cumulative O&M Investment (Millions 1999 $)	0	0	0	0	0	0	0	-2	-7	-8
Cumulative Consumer Investment (Millions 1999 $)	0	0	0	0	0	0	-3	-24	-81	-93

Cumulative lifecycle consumer investment is then calculated.

Cumulative Lifecycle Consumer Investment

Step (6)	2003	2004	2005	2006	2007	2010	2015	2020	2025	2030
Cumulative Lifecycle Capital Investment (Millions 1999 $)	0	0	0	0	0	-1	-11	-64	-124	-6
Cumulative Lifecycle O&M Investment (Millions 1999 $)	0	0	0	0	0	0	-1	-6	-12	-1
Cumulative Lifecycle Consumer Investment (Millions 1999 $)	0	0	0	0	0	-1	-13	-70	-137	-6

Calculating Net Economic Benefits

The net economic benefits of the advanced technology is a summation of public and private expenditures, energy cost savings, non-energy cost savings, and consumer investment. Calculations for annual, cumulative, and life cycle benefits will be performed by OPBM.