Appendix I – GPRA05 Solar Energy Technologies Program Documentation

GPRA Baseline Assumptions

Several changes from the *Annual Energy Outlook 2003 (AEO2003)* Reference Case were incorporated into the GPRA05 Baseline, in consultation with the Solar Energy Technologies Program. These changes include:

(1) Increasing the average commercial-building system size from 10kW to 100kW. A sample of data from 14 PV systems, installed between July 1999 and March 2003 by PowerLight Corporation, reveals that the average commercial system installed by PowerLight during this period was 381kW (**Table 1**).

Table 1. Commercial System Size and Surface-Area Requirements

PowerLight System Installation Location	Date Completed	Sytem Peak Capacity (kW)	PV Surface Area (sq. ft.)	W/sq.ft.
Santa Rita Jail - Alameda County, California	Apr-02	1,180	130,680	9.0
Cypress Semiconductor - San Jose, California	Jul-02	335	26,100	12.8
Fala Direct Marketing - Farmingdale, New York	Nov-02	1,010	102,700	9.8
Fetzer Vineyards, Hopland, California	Jul-99	41	3,750	10.9
Franchise Tax Board, Sacramento, California	Aug-02	470	50,000	9.4
Greenpoint Manufacturing - Brooklyn, New York	Mar-03	115	11,500	10.0
Mauna Lani Resort – Kohala Coast, Hawaii	Jan-02	528	43,330	12.2
Naval Base Coronado, California	Sep-02	924	81,470	11.3
Neutrogena Corporation - Los Angeles, California	Aug-01	229	30,154	7.6
Parker Ranch – Kameula, Hawaii	Jan-01	209	20,000	10.5
PSGA/Ortho-McNeil Facility - Pennsylvania	Apr-02	75	17,500	4.3
US Coast Guard – Boston, Massachusetts	Sep-99	37	3,800	9.7
US Postal Service - Marina del Rey, California	Nov-01	127	15,000	8.5
Yosemite National Park - Yosemite, California	Oct-01	47	4,500	10.4
Total		**5,327**	**540,484**	
Average		**381**	**38,606**	**10**

Source: PowerLight Case Study data sheets, downloaded from www.powerlight.com, 5/21/03.
Note: Some of the locations shown in this table have multiple installations. In these cases, the total installed capacity is shown above and the most recent installation date is shown in the date completed col.

The average space required for these systems was 10 sq. ft/W., based on a U.S. average commercial building size in 2000 of 14,500 square feet (AEO2003), and assuming a ratio of usable roof space to floor space of 0.7. This ratio of usable roof space to floor space was based on the "architecturally suitable area" in an International Energy Agency (IEA) report, Table 2, examining the potential for integrated photovoltaics in buildings (IEA 2001). Using this approximation, the average commercial building could easily accommodate a 100 kW PV system, i.e., a 0.7*14,500 sq. ft. = 10,100 sq. ft. PV array. Thus, setting the average system size at 100kW is a conservative assumption based on industry trends, as well as the available roof space on a large share (50+%) of the commercial building stock. This is a very conservative assumption based on the expectations that the efficiency of PV cells will increase; the space requirements for a PV system will decrease; and, as system costs decline, facades and other spaces (such as parking lots) also could be utilized for PV systems.

(2) Increasing the maximum share of commercial buildings with solar access from 30% to 55%. Similar to the preceding ratio of usable roof space to floor space, the share of roof space suitable for PV installations was based on the recently published IEA report on integrated photovoltaics in buildings (IEA 2001). This report indicates that a reasonable estimate for the share of roof space suitable for PV installations is 55%. This estimate includes shading and other factors that would limit the use of roof space for PV systems (IEA 2001).

(3) Increasing the average residential building system size from 2kW to 4kW. A couple of years ago, a typical residential rooftop PV system was a 2kW system—this is most likely the source for EIA's 2kW system size in the *AEO2003* reference case. However, residential rooftop systems being installed in Japan, Europe, and the United States have been growing larger. For example, the average Japanese rooftop system size in 2002 was 3.7 kW (Ikki 2003). The average home in the United States has 1,700 square feet of floor space (this is expected to increase). Using data from EIA's residential energy-consumption survey (EIA 1999, Table HC1-2a) one can estimate a floor- to roof-space ratio of 0.7 (based on distribution of one-story, two-story, and three-story single-family homes). This is a conservative estimate—most homes have pitched roofs, which would increase the total available roof space (yet may make a significant portion of the roof oriented away from the sun). If a typical system requires 10 sq. ft./W (as above), then a 4kW system would require roughly 400 square feet of roof space, which is well below the average available space allowing for multiple floors and pitched roofs. Thus, roof space is not a constraint for installing residential rooftop PV systems in the 4kW range. Because the efficiency of PV cells is likely to improve, a trend toward larger systems on rooftops is likely to continue. Thus, based on available roof space and what is happening in the marketplace, setting the average system size at 4kW is a conservative assumption.

(4) Increasing the maximum share of residential buildings with solar access from 30% to 60%. A maximum share of 60% for residential buildings with solar access was estimated by Walter Short (2003). This estimate includes building orientation, roof construction, roof equipment, and layout. This value was calculated from a combination of single-family homes (70%) and multifamily homes (30%), using a 75%–25% split between single-family and multifamily homes (EIA 2003, Table A4). Thus, the average maximum share is 0.7*0.75 + 0.3*0.25 = 0.6

(5) Including a declining PV buy-down program in California. This estimation assumed that the California renewable energy-credit program (which provided a PV credit of $4,000/kW in 2003) will continue to be available, but will decline by $400/kW per year. This credit was included for the entire Pacific region. Because a number of other local credits were not included in the GPRA baseline, applying the California state-level credit to the whole Pacific region is likely to be a reasonable approximation.

(6) Modifying the adoption rate of distributed generation technologies. The modification to the adoption rate was based on information provided by the DEER program (**Figure 1**). This applies to PV as well as gas-fired CHP technologies.

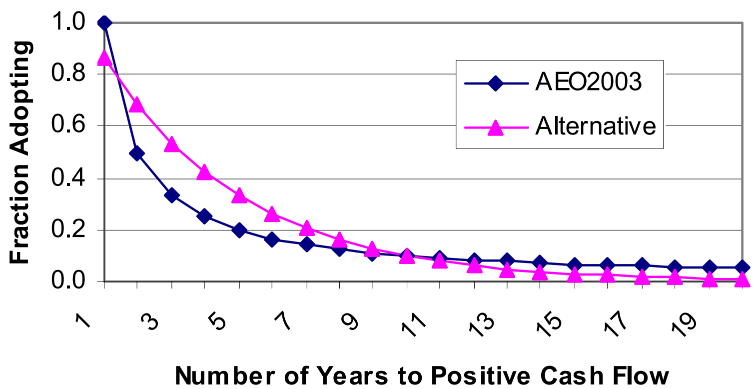

Figure 1. Commercial-Sector DG Adoption Rates

These changes lead to increased adoption of PV systems in the baseline. However, the *AEO2003* assumptions about PV installations through the Million Solar Roofs program were removed, so that there would not be double-counting when these were introduced in the GPRA Program Case.

One additional NEMS-GPRA05 model modification was made in the residential module. Solar water heaters were added as a technology option for new homes, and the algorithm governing water-heater replacements was modified so that solar water heaters could compete in a larger market.

GPRA05 Solar Program Scenario Assumptions

Two key sets of assumptions were modified to generate the GPRA05 Solar Energy Technologies Program scenario.

(1) Green power additions. Green power additions by region, from Princeton Energy Resources International (PERI), were added back into the Solar Program scenario (**Table 2**). These projections take into account the Baseline assumptions of noneconomic capacity additions. This capacity is added in NEMS-GPRA05 as "planned" additions. The capacity factors for the regions east of the Mississippi were assumed to be half of those for the western regions (EIA does not include CSP in these regions because it assumes that CSP is not cost-effective due to lower solar insolation levels).

Table 2. Incremental Green Power PV Capacity Additions (MW)

	2005	2006-2010	2011-2015	2016-2020	2021-2025	2005-2025
ECAR	7	81	198	159	50	495
ERCT	2	27	64	49	16	158
MAAC	6	75	179	142	44	447
MAIN	1	8	22	16	5	52
MAPP	0	5	13	12	4	34
NY	0	5	11	6	2	24
NE	0	7	15	10	3	35
FL	12	135	326	265	83	821
STV	36	406	978	795	248	2,464
SPP	3	30	72	57	18	180
NWPP	1	6	16	15	6	43
RA	1	11	28	22	8	70
CNV	0	0	1	6	4	11
Total	**70**	**796**	**1,923**	**1,554**	**491**	**4,834**

(2) Technology Characteristics. More aggressive technology targets were used. These technology characteristics were provided by the Solar Program for the range of solar technologies: concentrating solar power (CSP), central PV systems, distributed PV systems, and solar water-heating systems. Note that the CSP technology assumptions were not included in the final benefits analysis because it was not included in the FY05 Budget Request.

A multilab, multitechnology team was assembled to define a consistent set of long-term targets to 2050. This team produced technology cost projections for use in NEMS-GPRA05 that are consistent with the Solar Program's Multi-Year Technical Plan (which was being written concurrently to the GPRA05 analysis) and will soon be available on the EERE Web site. The Multi-Year Technical Plan includes cost targets though the 2020-2025 period (varying by technology). Thus, the targets shown in **Table 3** and **Table 4** are consistent with the Multi-Year Technical Plan through the 2020-2025 time frame. Beyond 2025, the targets are increasingly uncertain and are likely to be revised as the Solar Program continues to analyze the long-term prospects for PV technology cost reductions. Although the costs shown below are for specific years, the costs decline annually between years.

Table 3. PV Systems

	Central Generation		Residential Buildings		Commercial Buildings	
Year	Installed Price (2001$/kW)	O$M (2001$/kW)	Installed Price (2000$/kW)	O$M (2000$/kW)	Installed Price (2000$/kW)	O$M (2000$/kW)
2003	5,300	60	9,450	160	6,250	160
2007	3,600	40	6,250	40	4,500	40
2020	2,000	10	2,800	10	2,800	10
2025	1,700	9	2,380	9	2,380	9
2050	1,050	5	1,470	5	1,470	5

Two solar water heaters, which have different efficiencies or electric backup requirements, are represented

Table 4. Residential Solar Water Heat

		Best (High efficiency)			Minimum (Typical efficiency)		
First Year	Last Year	Efficiency	Total Installed Cost($01)	Retail Equipment Cost($01)	Efficiency	Total Installed Cost($01)	Retail Equipment Cost($01)
1997	2004	2.5	2800	1250	2.0	2300	1200
2005	2009	2.6	2200	1000	2.1	2000	1000
2010	2019	2.7	1400	700	2.2	1000	500
2020	2025	3.0	1200	600	2.5	800	400
2026	2030	3.5	1020	510	2.7	680	340
2031	2035	4.0	867	434	2.8	578	289
2036	2040	4.5	780	390	2.9	520	260
2041	2050	5.0	741	371	3.0	494	247

References

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