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VANDENBERG AIR FORCE BASE
INTEGRATED RESOURCE ASSESSMENT

VOLUME 1: EXECUTIVE SUMMARY

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ABSTRACT

Some of the most difficult problems encountered at federal sites in reducing energy consumption in a cost-effective manner revolve around understanding where the energy is being used and what technologies can be employed to decrease energy use. Many large federal sites have one or two meters to track electric energy use for several thousand buildings and numerous industrial processes. When meters are located on individual buildings or family housing units, they are not consistently read. When the federal energy manager has been able to identify high energy users, the energy manager may not have the background, training, or resources to determine the most cost-effective options for reducing this energy use. This limitation can lead to selecting suboptimal projects that prevent the site from achieving full life-cycle cost (LCC) savings.

The U.S. Air Force (USAF) Space Command (SPACECOM) has tasked the Pacific Northwest Laboratory (PNL),[a] in support of the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP), to develop a model program that provides a systematic approach to evaluating energy opportunities. The program 1) identifies the building groups and end uses using the most energy (not just having the greatest energy-use intensity [EUI]) and 2) evaluates numerous options for retrofitting or installing new technology that will result in selecting the most cost-effective technologies. In essence, this model program provides the federal energy manager with a road map to significantly reduce energy use in a planned, rational, cost-effective fashion that is not biased by the constraints of the typical funding sources available to federal sites. The results from this assessment process can easily be turned into a 5- to 10-year energy management plan that identifies where to start and how to proceed to reach the mandated energy consumption targets.

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This report provides the results of the fossil fuel and electric energy resource opportunity (ERO) assessments performed by PNL at the USAF SPACECOM facility, Vandenberg Air Force Base (AFB), located near Lompoc, California. This is a companion report to Volume 2: Baseline Detail (Halverson et al. 1993) and Volume 3: Resource Assessment (Daellenbach et al. 1993a).

SUMMARY

The federal government is the single largest energy consumer in the United States, with an annual consumption of 1.46 quads of energy during fiscal year (FY) 1991. Evidence suggests enormous energy and dollar savings potential exists within the federal sector. With the implementation of the most life-cycle cost-effective technologies, between 25% and 40% of the annual energy bill for buildings and facilities (about 30% of the total federal energy consumption) can be saved. On October 24, 1992, the Energy Policy Act of 1992 (EPAct, Public Law 102-486) was issued. EPAct directs federal agencies to reduce energy consumption by 20% from 1985 levels by the year 2000. Executive Order 12902 increases the goal for federal energy savings to 30% by the year 2005 (59 FR 11463). To assist federal agencies in meeting this direction, the U.S. Air Force (USAF) Space Command (SPACECOM) has tasked the Pacific Northwest Laboratory (PNL), in support of the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP), to identify, evaluate, and acquire all cost-effective energy projects at selected federal facilities.

This report provides the results of the fossil fuel and electric energy resource opportunity (ERO) assessments performed by PNL at the USAF SPACECOM facility, Vandenberg Air Force Base (AFB), located near Lompoc, California. This is a companion report to Volume 2: Baseline Detail (Halverson et al. 1993) and Volume 3: Resource Assessment (Dallenbach et al. 1993a).

Vandenberg AFB is a 98,400-acre SPACECOM facility situated along the Pacific coast, east of Lompoc, California and southwest of Santa Maria, California. The primary mission of Vandenberg AFB is to launch and track polar-orbiting space satellites and intercontinental ballistic missiles. More than 40 U.S. Department of Defense (DoD) and non-DoD government organizations are located at Vandenberg AFB, along with more than 60 civilian aerospace contractors. The base population includes between 5,000 and 7,000 full-time residents and a varying number of contractor employees. Contractor employment

has been as high as 8,600 people, giving a "total" base population approaching 15,000.

To determine an energy consumption baseline, the base was divided into the following three major areas: commercial, family housing, and utility. Two of these areas had structures totaling 2,274 buildings with a total area of 10,896,000 ft^2. On-post utilities include electricity, natural gas, water, fire protection, and sewage. Delivered fuels include No. 2 fuel oil and propane.

In FY91, total building energy consumption at Vandenberg AFB was 1,464,000 MBtu at a cost of $15,794,000. Characteristic energy types included electricity, natural gas, No. 2 fuel oil, and propane. Electricity and natural gas made up over 80% of the energy consumption and over 95% of the energy cost. End uses for electricity included heating, fans/pumps, lighting, cooling, cooking, refrigeration, domestic hot water, process, and other. Lighting made up over 30% of the electric energy consumption. Fossil fuel end uses included space heating, hot water, cooking, and other. Space heating made up over one-half of total energy consumption.

Nonbuilding energy use includes unleaded gasoline and diesel fuel used by base vehicles. Approximately 670 USAF and 547 General Services Administration vehicles are on base. Baseline vehicle fuel use data was unavailable at the time this report was completed.

Following life-cycle cost (LCC) guidelines required for all federal energy decisions (10 CFR 436), PNL prioritized the various energy resource opportunities (EROs) by 10 end-use categories (e.g., lighting, hot water, heating). The present value (PV) of the installed cost of all cost-effective EROs at Vandenberg AFB is approximately $18.3 million (1992 dollars) and the PV of the savings associated with this investment is approximately $45.7 million (1992 dollars), for an overall net present value (NPV) of $27.4 million.

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We also wish to acknowledge all the individuals associated with preparing and writing Volume 2: Baseline Detail (Halverson et al. 1993) and Volume 3: Resource Assessment (Dallenbach et al. 1993a) for their assistance in preparing this document.

In addition, the authors thank the PNL text processing team and editor, Dave Payson, for the conscientious, high-quality assistance they brought to the Vandenberg Air Force Base assessment.

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ABBREVIATIONS AND ACRONYMS

AFB	Air Force Base
Btu	British thermal unit
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DSM	demand-side management
ECIP	Energy Conservation Investment Program
EPAct	Energy Policy Act of 1992
ERO	energy resource opportunity
EUI	energy-use intensity
FEDS	Facility Energy Decision Screening
FEMP	Federal Energy Management Program
FY	fiscal year
hp	horsepower
kVA	kilovoltampere
kW	kilowatt
kWh	kilowatt-hour
kW-mo	kilowatt-month
LCC	life-cycle cost
NIST	National Institute of Standards and Technology
NPV	net present value
MBtu	million British thermal units
MILCON	military construction
MWh	megawatt-hour
O&M	operations and maintenance
PG&E	Pacific Gas and Electric Company
PNL	Pacific Northwest Laboratory
PV	present value
RI	replace immediately
ROF	replace-on-failure
SIR	savings-to-investment ratio
SLC	space launch complex
SPACECOM	Space Command
SVPP	South Vandenberg power plant
T&D	transmission and distribution
USAF	U.S. Air Force
yr	year

1.0 INTRODUCTION

Nearly 2.4% of all energy used in the United States is consumed by the federal government in buildings, facilities, and operations, making it the single largest energy consumer in the country. In fiscal year (FY) 1991, the federal government consumed nearly 1.46 quads[a] of energy annually at a cost of $11.26 billion. Of this, buildings and facilities consumed 0.41 quads at a cost of $3.75 billion (DOE 1992). Evaluations (completed and ongoing) by Pacific Northwest Laboratory (PNL) at over 50 federal installations indicate an enormous energy and dollar savings potential exists within the federal sector. Evidence suggests there is a potential to save 25% to 40% of the annual energy bill by implementing the most life-cycle cost-effective technologies (Currie 1992). Furthermore, a level of investment of $5 billion to $10 billion between now and the year 2000 has the potential of saving $2 billion annually in the federal sector (Currie 1992). This investment will be applied toward retrofitting and replacing current lighting, motor, transformer, water heating, space cooling, space heating, process, and vehicle equipment with new and more efficient technologies.

In line with the Energy Policy Act of 1992 (EPAct, Public Law 102-486), federal agencies have set a goal to reduce federal facility energy use and increase industrial process efficiency improvement by 20% the year 2000 (from 1985 levels). Executive Order 12902 increases the goal for federal energy savings to 30% by the year 2005 (59 FR 11463). This direction requires purchasing the most life-cycle cost-effective energy-consuming goods or products available. Other legislation affecting energy conservation goals in the federal sector include the life-cycle cost (LCC) methods and procedures referred to in 10 CFR 436.

The 10 CFR 436 legislation mandates the use of LCC methods and procedures by all federal agencies for the design of new federal buildings and the

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(a) One quad is equivalent to 1 quadrillion (10^{15}) Btu of energy.

application of energy conservation measures to existing buildings. EPAct addresses energy, environmental, and economic issues in a coordinated and comprehensive manner. It encourages investment in conservation and energy efficiency by gas and electric utilities by allowing utilities to recover the cost of demand-side management (DSM) incentives through rate recovery. EPAct authorizes and encourages federal agencies to participate in utility incentive programs to increase energy efficiency and conserve water.

The U.S. Department of Defense (DoD), with hundreds of installations worldwide, massive aviation fuel needs, and approximately 335,000 buildings, is the largest energy consumer within the federal government, consuming approximately 87.1% of the total. The DoD controls 1.94 billion square feet of federal buildings (69.0% of the total federal real property) with a total real property cost of $79.9 billion (48.6% of the total real property cost) (GSA 1989). Model programs being developed by PNL for DSM at DoD installations can set the standard for energy efficiency for all DoD and federal installations. These DSM programs are being deployed at several DoD installations.

Some of the most difficult questions a federal site has to address in reducing its energy consumption in a cost-effective manner include where energy is being used and what technologies can be employed to decrease energy use. Many large federal sites have one or two meters to track electric energy use for several thousand buildings and numerous industrial processes. When meters are located on individual buildings or family housing units, they are not consistently read. When the federal energy manager has been able to identify high energy users, the energy manager may not have the background, training, or resources to determine the most cost-effective options for reducing this energy use. This limitation can lead to selecting suboptimal projects that prevent the site from achieving the full LCC savings.

The model program developed by the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) constitutes a systematic approach to evaluating energy resource opportunities (EROs). The program 1) identifies

the building groups and end uses using the most energy (not just having the greatest energy-use intensity [EUI]) and 2) evaluates the numerous options for retrofitting or installing new technology that will result in selecting the most cost-effective technologies. In essence, this model program provides the federal energy manager with a road map to significantly reduce energy use in a planned, rational, cost-effective fashion that is not biased by the constraints of the typical funding sources available to federal sites. The results from this assessment process can easily be turned into a 5- to 10-year energy management plan that identifies where to start and how to proceed to reach the mandated energy consumption targets.

To assist federal agencies in meeting the direction of EPAct, DOE FEMP, supported by PNL, has been tasked by the U.S. Air Force (USAF) Space Command (SPACECOM) to identify, evaluate, and acquire all cost-effective energy projects at selected federal facilities. FEMP's mission is to improve the efficiency and fuel flexibility of energy use in federal buildings, transportation, and operations; and to facilitate the transfer of energy management experience among federal agencies. At Vandenberg Air Force Base (AFB), FEMP is designing a model program for federal customers served by the Pacific Gas and Electric Company (PG&E). This program will 1) identify and evaluate all electric and fossil fuel cost-effective energy projects; 2) develop a schedule for project acquisition, considering project type, size, timing, and capital requirements, as well as energy and dollar savings; and 3) secure 100% of the financing required to implement electric energy efficiency projects from PG&E, and have PG&E procure the necessary contractors to perform detailed audits and install technologies.

This report provides a summary of the energy-use baseline information found in Volume 2: Baseline Detail (Halverson et al. 1993) and the assessment of EROs found in Volume 3: Resource Assessment (Daellenbach et al. 1993a). In addition, this report summarizes a strategy for implementing this conservation and fuel-switching potential.

The Vandenberg AFB installation is characterized in Section 2.0. A baseline of energy use is found in Section 3.0. The analytical approach for determining EROs is described in Section 4.0, with a summary of resource assessment results in Section 4.1. Section 5.0 describes a strategy for implementing EROs, and the conclusions and recommendations are found in Section 6.0. References are listed in Section 7.0, and the LCC methodology is provided in Appendix A. The Vandenberg AFB Extended Energy Project Implementation Structure is provided in Appendix B.

2.0 SITE CHARACTERIZATION

Vandenberg AFB is a 98,400-acre (154-mi^2) USAF SPACECOM facility situated along the Pacific coast, east of Lompoc, California and southwest of Santa Maria, California at 34°N latitude and 120°W longitude. The primary mission of Vandenberg AFB is to launch and track polar-orbiting space satellites and intercontinental ballistic missiles.

More than 40 DoD and non-DoD government organizations are located at Vandenberg AFB, along with more than 60 civilian aerospace contractors. The base population includes between 5,000 and 7,000 full-time residents and a varying number of contractor employees. Contractor employment has been as high as 8,600 people, giving a total base population approaching 15,000.

The base is divided into three major areas for energy consumption and billing purposes: commercial, family housing, and utility (including exterior lighting, pumping, and transmission and distribution [T&D] losses). Commercial buildings are a mix of older wood frame construction and newer metal frame and curtain wall construction, with some stone/brick construction. Family housing is primarily wood frame construction with little or no insulation in the walls or ceilings. Table 2.1 shows the total number of buildings in each area and the total square feet for each of the areas.

TABLE 2.1. Vandenberg AFB Building Characterization

Base Area	Total Number of Buildings	Total Floor Area (ft^2)	Percent of Total Floor Area
Commercial	3,099	8,122,370	74.5
Family Housing	1,913	2,773,765	25.5
Total	5,012	10,896,135	100.0

3.0 ENERGY-USE BASELINE

This section describes the energy-use baseline at Vandenberg AFB. The analysis used to determine an energy-use baseline examines the characteristics of electricity, natural gas, No. 2 fuel oil, and propane for FY91. This analysis also breaks down building energy consumption by fuel type, energy end use, and building type. A complete energy consumption reconciliation is presented that accounts for the distribution of energy use among buildings, utilities, central systems, and distribution losses. Table 3.1 shows a summary of the typical annual energy consumption and cost for all facilities at Vandenberg AFB. For each energy type, the annual total is shown in units appropriate to the energy type and in a common unit as a basis for comparison. The total consumption values represent typical current annual usage from the best available data during 1991. The annual total energy consumption was 1,464,998 MBtu at a cost of $15,794,162. Incomplete information was available to characterize fuel use (gas and diesel) by base vehicles, so this characterization is not included in the energy-use baseline totals.

TABLE 3.1. Typical Annual Energy Consumption and Cost at Vandenberg AFB

Energy Type	Total Consumption in Purchase Units	Total Consumption (MBtu)[a]	Percent of Total Consumption	Total Energy Cost (1991$)	Percent of Total Cost
Electricity	199,810 MWh	681,787[b]	46.5	10,960,446	69.4
Natural Gas	6,840 ktherm	684,000[c]	46.7	4,078,990 (est)	25.8
No. 2 Fuel Oil	343 kgal	47,600[d]	3.3	353,290	2.3
Propane	532 kgal	50,452[e]	3.5	401,436	2.5
Total		1,463,998	100.0	15,794,162	100.0

(a) 1 MBtu = 1,000,000 Btu
(b) 3,413 Btu/kWh
(c) 100,000 Btu/therm
(d) 0.1387 MBtu/gal
(e) 0.095 MBtu/gal

Table 3.2 breaks down energy consumption by fuel type and end use for the base's three major areas. Utility readings, fuel delivery records, and various building meters were used to determine the total energy consumption by building type within each area. These data, with EUI estimates, were used to reconcile the energy consumption by building type and end-use category (e.g., lighting, heating, cooling).

Energy consumption is shown in Figures 3.1, 3.2, 3.3, 3.4, and 3.5. Figure 3.1 shows energy use by fuel type, Figure 3.2 shows energy use by facility sector, Figure 3.3 shows energy use by end use for all fuels, Figure 3.4 shows energy use by end use for electricity, and Figure 3.5 shows energy use by end use for fossil fuels.

TABLE 3.2. Energy Consumption by End Use at Vandenberg AFB (MBtu/yr)

Fuel Type/End Use	Commercial	Family Housing	Utility	Total	Percent of Total
Electricity:					
Lighting	135,810	12,304	0	148,114	21.7%
Heating	11,349	0	0	11,349	1.7%
Cooling	8,353	0	0	8,353	1.2%
Vents/Fans	55,731	945	0	56,676	8.3%
Domestic Hot Water	2,498	0	0	2,498	0.4%
Cooking	58	188	0	246	0.0%
Refrigeration	11,424	12,304	0	23,728	3.5%
Other	56,526	21,769	0	78,295	11.5%
Process	126,799	0	0	126,799	18.6%
Water Supply	0	0	12,249	12,249	1.8%
Sewage Treatment	0	0	1,201	1,201	0.2%
Transformer Losses	0	0	23,734	23,734	3.5%
Street/Lot Lighting	0	0	2,966	2,966	0.4%
Non-Bldg Process 1 (Tracking)	0	0	105,803	105,803	15.5%
Non-Bldg Process 2 (Launch Support)	0	0	38,908	38,908	5.7%
Reimbursables	40,755			40,755	6.0%
Totals	449,303	47,510	184,861	681,674	100.0%
Percent of Total:	65.9%	7.0%	27.1%		
Natural Gas:					
Heating	278,484	69,344	0	347,828	54.5%
Domestic Hot Water	141,106	55,475	0	196,581	30.8%
Cooking	3,931	13,869	0	17,800	2.8%
Other	6,847	0	0	6,847	1.1%
South Vandenberg Power Plant	0	0	54,607	54,607	8.6%
Other Power Plants	0	0	10,921	10,921	1.7%
Nonreimbursables	3,403	0	0	3,403	0.5%
Totals	433,771	138,688	65,528	637,987	100.0%
Percent of Total:	68.0%	21.7%	10.3%		
No. 2 Fuel Oil:					
Heating	37,765	0	0	37,765	75.6%
Domestic Hot Water	5,388	0	0	5,388	10.8%
South Vandenberg Power Plant	0	0	4,043	4,043	8.1%
Other Power Plants	0	0	2,327	2,327	4.7%
Emergency Power Plants	0	0	450	450	0.9%
Totals	43,153	0	6,820	49,973	100.0%
Percent of Total:	86.4%	0.0%	13.6%		
Propane:					
Heating	32,420	0	0	32,420	64.3%
Domestic Hot Water	16,777	0	0	16,777	33.3%
Cooking	79	0	0	79	0.2%
Non-Bldg Process	0	0	1,176	1,176	2.3%
Totals	49,276	0	1,176	50,452	100.0%
Percent of Total:	97.7%	0.0%	2.3%		
Grand Total:	975,503	186,198	258,385	1,420,086	
Percent of Total:	68.7%	13.1%	18.2%	100.0%	

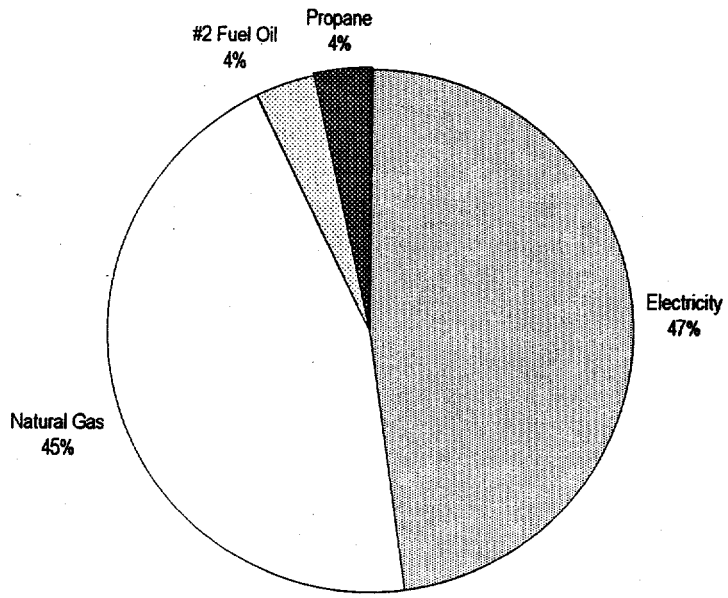

FIGURE 3.1. Energy Use by Fuel Type (MBtu)

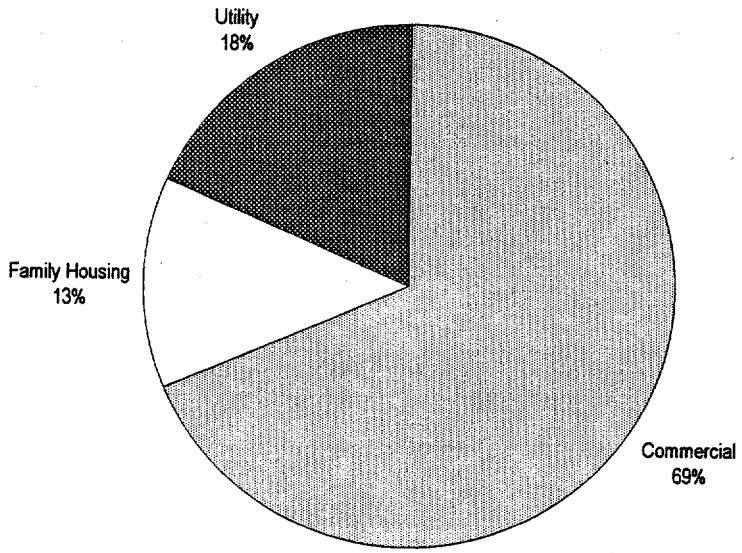

FIGURE 3.2. Energy Use by Facility Sector (MBtu)

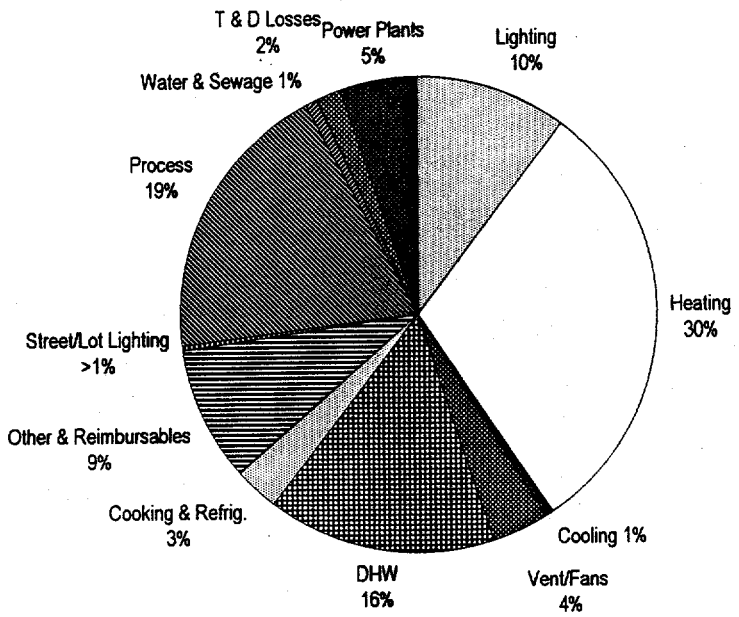

FIGURE 3.3. Energy Use by End Use for All Fuels (MBtu)

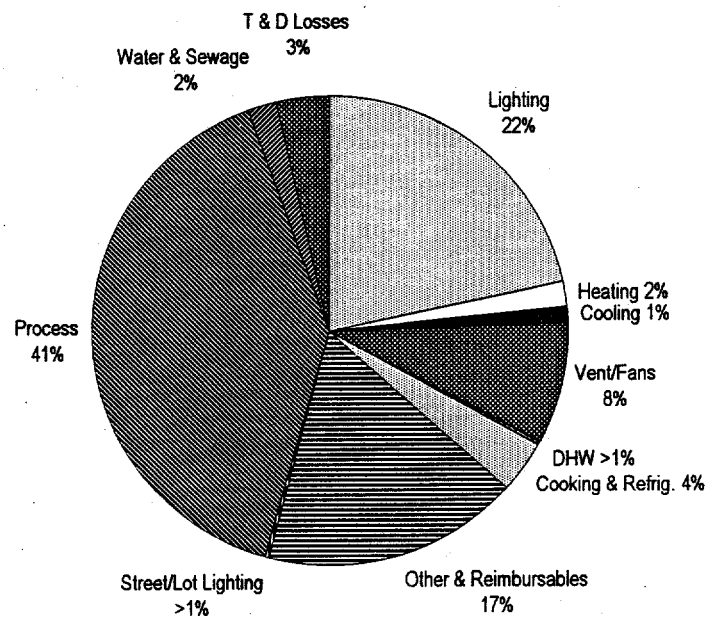

FIGURE 3.4. Energy Use by End Use for Electricity (MBtu)

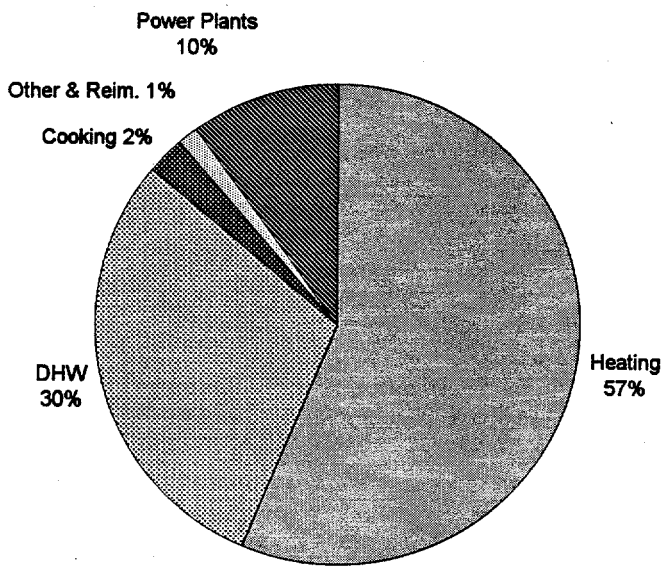

FIGURE 3.5. Energy Use by End Use for Fossil Fuels (MBtu)

4.0 ENERGY RESOURCE OPPORTUNITIES

The number of conceivable energy conservation measures, fuel-switching opportunities, and renewable-energy projects at a federal site is very large. A three-step process has been developed by PNL to make ERO selection, evaluation, and prioritization manageable. The steps are as follows:

- Preliminary Screening. Select promising EROs from a master list, considering the site's mission, building stock, end-use equipment characteristics, utility characteristics, climate, energy costs, other local conditions affecting ERO viability, and recommendations from site staff.

- Cost and Performance Analysis. Establish, with a reasonable degree of accuracy, the technical and economic feasibility of each ERO that passed the preliminary screening. Perform an analysis to compare the operating and economic performance of existing equipment and the ERO. Where applicable, impacts on energy security and the environment are included in the analysis.

- Life-Cycle Cost Analysis and Prioritization. Perform an LCC analysis and rank EROs by net present value (NPV) so a package with the optimal return on investment can be defined. If any utility cost-sharing or rebate programs exist, they can be included within this evaluation step.

The LCC analysis and prioritization step is required by federal law (10 CFR 436). All federal agencies are required to evaluate the LCC of alternative technologies when making energy investments. An LCC evaluation computes the total long-run costs of alternative actions and identifies the action that maximizes the NPV of the energy investment. These requirements are discussed in more detail in Appendix A.

4.1 RESULTS OF ERO ASSESSMENT

This section summarizes the ERO analysis results and aggregates the savings potential into major end-use categories. The specific EROs are described in detail in the Volume 3: Resource Assessment report (Daellenbach et al. 1993a). Analysis results are presented in 10 common energy end-use categories (e.g., boilers and furnaces, service hot water, and building lighting).

As illustrated in Table 4.1, the present value (PV) of the installed cost of all EROs constituting the minimum LCC efficiency resource (i.e., cost-effective) at Vandenberg AFB is approximately $18.3 million in 1992 dollars (1992$). The PV of the savings associated with this investment is approximately $45.7 million, for an overall NPV of $27.4 million.

TABLE 4.1. Total Cost, Savings, and NPV at Vandenberg AFB (1992$)

Total PV of Installed Cost	Total PV of Energy Savings	Total PV of Demand Savings	Total PV of O&M Savings	Total PV of Replacement Savings	Total PV of All Savings	Total NPV
18,346,343	24,458,892	7,081,085	8,950,165	5,221,154	45,711,296	27,364,953

Table 4.2 provides a breakdown and summary of the cost-effective electric EROs at Vandenberg AFB. Cost-sharing and rebate incentives from the utility would normally be factored into the analysis. Although the potential DSM relationship with the electric utility, PG&E, is proceeding, USAF SPACECOM and Vandenberg AFB project managers agreed that the Vandenberg AFB reports (Volume 2 [Halverson et al. 1993], Volume 3 [Daellenbach et al. 1993a] and this report) would present an economic analysis from the government-funding-only perspective. Thus, if no cost-sharing with the utility could be arranged, the document would still be useful to the USAF in planning the implementation of various EROs. Once details of a cost-sharing agreement with the utility have been reached, the economic analysis can be redone at any time.

The operations and maintenance (O&M) savings are a reflection of the incremental cost difference between the cost of maintaining the existing equipment and that of maintaining new or retrofitted equipment. Because

TABLE 4.2. Summary of Cost-Effective Electric EROs at Vandenberg AFB (1992$)

ERO Category	PV of Installed Cost	PV of Energy Savings	PV of Demand Savings	PV of O&M Savings	PV of Replace. Savings	PV of Total Savings	NPV
Lighting	6,712,768	7,132,365	2,046,905	5,071,339	0	14,250,609	7,537,840
Motors	270,223	1,493,715	16,145	0	152,538	1,662,398	1,392,176
T&D	6,727,565	1,475,090	195,336	0	5,794,344	7,464,770	737,205
SVPP[a]	0	5,872,259	4,886,082	-59,314	0	10,699,027	10,699,027
Totals	13,710,556	15,973,429	7,144,468	7,999,110	5,946,882	34,076,804	20,366,248

(a) See Appendix in Volume 3: Resource Assessment (Daellenbach et al. 1993a). The South Vandenberg power plant (SVPP) O&M saving consists of $560,288 credit from the sale of emission permits, less $619,602 increased O&M. SVPP reported values are for 1994. Generation will decline over time. While the analysis discussed in the Volume 3: Resource Assessment report uses a 4.6% discount rate, the SVPP analysis (Daellenbach et al. 1993b) uses a 4.0% discount rate.

maintenance costs of new or retrofitted equipment are often the same as the costs to maintain existing equipment, this incremental maintenance cost is often zero.

Table 4.3 accompanies Table 4.2. Table 4.3 presents a breakdown and summary of both the electric energy and demand savings for the first year and full implementation of the cost-effective electric EROs at Vandenberg AFB.

Table 4.4 provides a breakdown and summary of cost-effective fossil fuel EROs at Vandenberg AFB. The economic analysis presented below considered only natural gas and propane. Potential EROs affecting fuel oil use were considered in the initial screening evaluation, but it was determined in discussions with Vandenberg AFB personnel that, because Vandenberg AFB was already phasing-out the use of fuel oil wherever possible, these EROs would not be considered further. This phase-out is primarily a result of increasing restrictions on air emissions mandated by the Santa Barbara Air Pollution Control District.

TABLE 4.3. Summary of Electric Energy and Demand Savings at Vandenberg AFB

ERO Category	First-Year Energy Savings (MBtu)	Full Implement. Energy Savings (MBtu)	First-Year Demand Savings (kW-mo)	Full Implement. Demand Savings (kW-mo)
Lighting	31,586	31,586	27,279	27,279
Motors	6,776	7,051[a]	215	215[b]
T&D	0	10,775[a]	0	4,325
SVPP[c]	(c)	(c)	(c)	(c)
Totals	38,362	49,412	27,494	31,819

(a) The energy savings increase between the first year and full implementation because of an additional implementation of replace-on-failure (ROF) opportunities.

(b) The full implementation demand saving for motors does not increase over the first-year demand saving because of an uncertainty about the ROF motor contribution to the monthly peak demand.

(c) See Appendix in Volume 3: Resource Assessment (Daellenbach et al. 1993a). First-year energy and demand savings will be 234,440 MBtu and 51,300 kW-mo, respectively. During the remaining 17-year life of the gas turbines at the SVPP, electricity generation and the related natural gas use will decline over time, resulting in reduced energy and demand savings for subsequent years.

TABLE 4.4. Summary of Cost-Effective Fossil Fuel EROs at Vandenberg AFB (1992$)

ERO Category	PV of Installed Cost	PV of Energy Savings	PV of O&M Savings	PV of Replacement Savings	PV of Total Savings	NPV
Space Heating	1,745,786	2,858,824	0	318,463	3,177,287	1,431,501
Transportation[a]	892,398	2,598,956	2,987,085	(1,160,588)	4,425,453	3,533,055
Water Heating	141,833	719,219	0	(102,152)	617,066	475,234
Totals	2,780,017	6,176,999	2,987,085	(944,277)	8,219,806	5,439,790

(a) This category consists of all options to switch from gas and diesel to compressed natural gas in on-base vehicles.

Table 4.5 accompanies Table 4.4. Table 4.5 presents a breakdown and summary of both the energy and demand savings for the first year and full implementation of the cost-effective fossil fuel EROs at Vandenberg AFB.

TABLE 4.5. Summary of Fossil Fuel Energy and Demand Savings at Vandenberg AFB

ERO Category	First-Year Energy Savings (MBtu)	Full Implement. Energy Savings (MBtu)	First-Year Demand Savings (kW-mo)	Full Implement. Demand Savings (kW-mo)
Space Heating	27,860	27,860	0	0
Transportation	20,406	20,410[a]	0	0
Water Heating	5,470	8,339[a]	0	0
Totals	3,736	56,609	0	0

(a) Energy saving increases between first year and full implementation because of additional implementation of ROF opportunities.

Because of time, funding, and information availability constraints, the scope of this assessment only considered process energy conservation at the space launch complex (SLC)-4. Table 4.6 provides a breakdown and summary of the cost-effective process ERO developed for the case study at SLC-4. This SLC was chosen for the following reasons:

1) SLC-4 has the greatest energy use of any active SLC, and therefore has potential for a large energy savings impact.

2) Because of the secure nature of the missions at the SLCs, significant assistance was required from SLC operating personnel to obtain the necessary data for economic analysis. This type of assistance was only provided at SLC-4.

3) The SLC-4 mission is relatively stable compared to the transient nature of the missions at other SLCs. For example, the SLC-5 mission to launch Scout missiles will be changing when the current supply of Scout missiles is depleted (about 3 years).

The SLC-4 analysis is generally conservative because this SLC is the most modern at Vandenberg AFB. Consequently, energy savings are more difficult to achieve. Although differences exist between process and procedure requirements in handling the different vehicle types, energy conservation at the other SLCs may be possible by applying some of the EROs considered at SLC-4.

TABLE 4.6. Summary of Cost-Effective Process ERO at Vandenberg AFB SLC-4 (1992$)

ERO Category	PV of Installed Cost	PV of Energy Savings	PV of Demand Savings	PV of O&M Savings	PV of Replacement Savings	PV of Total Savings	NPV
Process	1,855,800	2,308,464	(63,383)	951,055	218,549	3,414,685	1,558,883

Table 4.7 accompanies Table 4.6. Table 4.7 presents a breakdown and summary of both the energy and demand savings for the first year and full implementation of the cost-effective process ERO at Vandenberg AFB.

Table 4.8 presents a breakdown and summary of the cost-effective EROs determined within this ERO assessment by fuel type.

TABLE 4.7. Summary of Process Energy and Demand Savings at Vandenberg AFB

ERO Category	First-Year Energy Saving (MBtu)	Full Implement. Energy Saving (MBtu)	First-Year Demand Saving (kW-mo)	Full Implement. Demand Saving (kW-mo)
Process	4,966	4,966	-842[a]	-842

(a) The negative demand saving is a result of the increased demand for electricity because of a fuel switch from nitrogen.

Table 4.9 accompanies Table 4.8. Table 4.9 presents a breakdown and summary of both the energy and demand savings for the first year and full implementation for different fuel types at Vandenberg AFB.

Energy resource potential is shown in Figures 4.1, 4.2, and 4.3. Figure 4.1 shows the NPV for all EROs, Figure 4.2 shows the energy savings for all EROs, and Figure 4.3 shows the annualized energy and demand cost savings.

TABLE 4.8. Summary of Cost-Effective EROs by Fuel Type at Vandenberg AFB

Fuel Type	PV of Installed Cost	PV of Energy Savings	PV of Demand Savings	PV of O&M Savings	PV of Replacement Savings	PV of Total Savings	NPV
Propane	38,345	153,795	0	0	7,342	161,119	122,774
Natural Gas	1,849,274	3,424,248	0	0	208,987	3,633,235	1,783,961
Electricity	13,710,556	10,101,170	2,258,386	5,071,339	5,946,882	23,377,777	9,667,221
Fuel Switch [a,b]	2,748,198	10,779,679	4,822,699	3,878,826	(942,039)	18,539,165	15,790,965
Total	18,346,373	24,458,892	7,081,085	8,950,165	5,221,154	45,711,296	27,264,921

(a) The SVPP O&M saving consists of $560,288 credit from sale of emission permits, less $619,602 increased O&M. While the analysis for the Volume 3: Resource Assessment report (Daellenbach et al. 1993a) used a 4.6% discount rate, the SVPP analysis (Daellenbach et al. 1993b) used a 4.0% discount rate.

(b) Fuel switch includes process, transportation, and SVPP EROs.

TABLE 4.9. Summary of Energy and Demand Savings by Fuel Type at Vandenberg AFB

ERO Category	First-Year Energy Savings (MBtu)	Full Implement. Energy Savings (MBtu)	First-Year Demand Savings (kW-mo)	Full Implement. Demand Savings (kW-mo)
Electricity	38,362	49,412[a]	27,494	31,819
Fuel Switch[b]	25,372	25,376[a]	-842[c]	-842
Natural Gas	31,818	34,685[c]	0	0
Propane	1,514	1,514	0	0
Total[d]	97,066	110,987	26,652	30,977

(a) The energy savings increase between the first year and full implementation because of an additional implementation of ROF opportunities.

(b) Fuel switch includes process, transportation, and SVPP EROs.

(c) The negative demand saving is a result of the increased demand for electricity because of a fuel switch from nitrogen.

(d) See the SVPP analysis in the economic analysis report for Vandenberg AFB (Daellenbach et al. 1993b). Energy and demand savings for the SVPP, which are not included, are 234,440 MBtu and 51,300 kW-mo, respectively. During the remaining 17-year life of the gas turbines at the SVPP, electricity generation and related natural gas use will decline over time, resulting in reduced energy and demand savings for subsequent years.

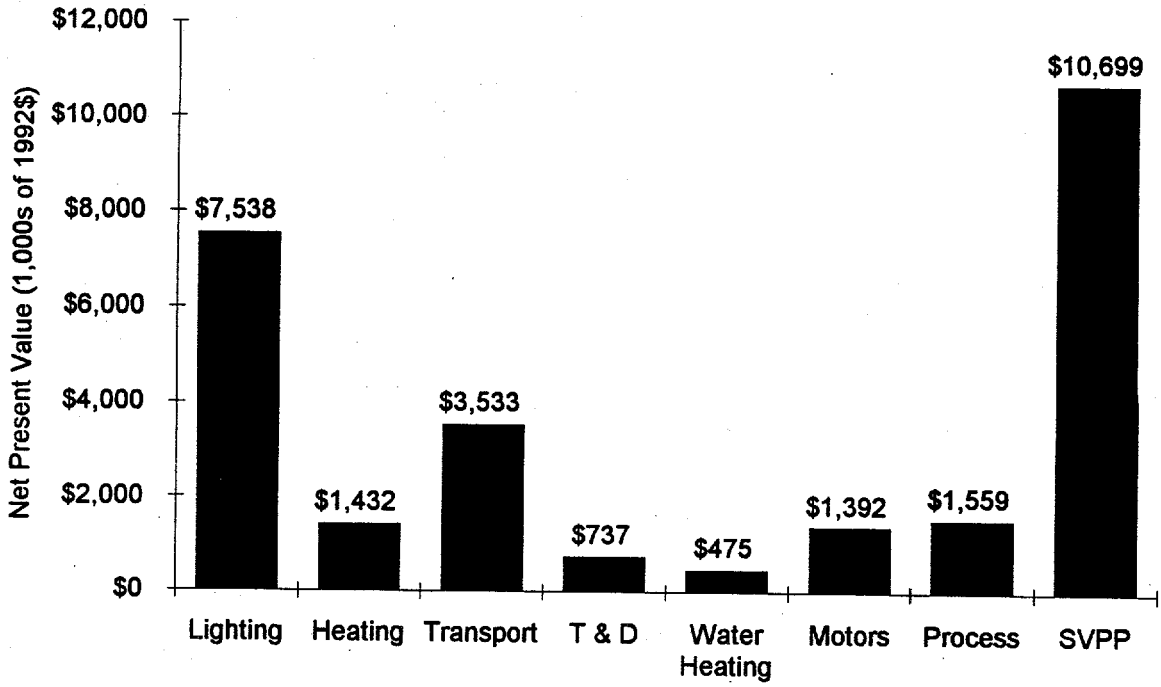

FIGURE 4.1. Net Present Value for All EROs by ERO Category

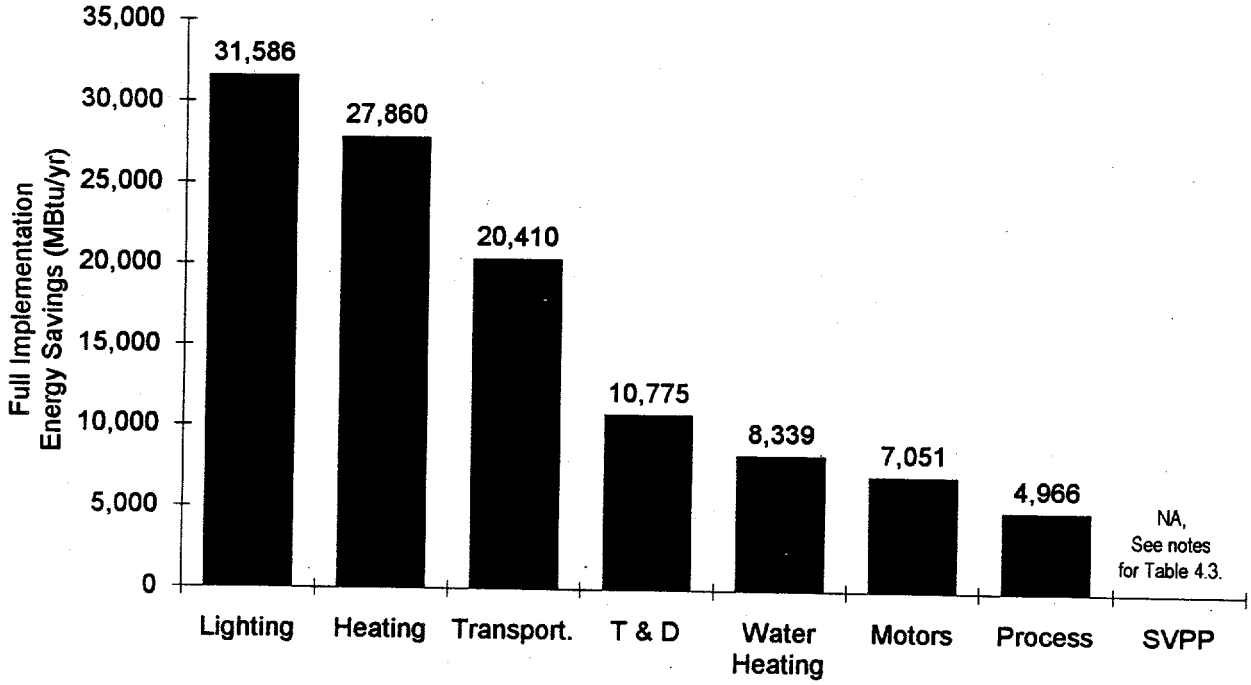

FIGURE 4.2. Full Implementation Annual Energy Savings for All EROs

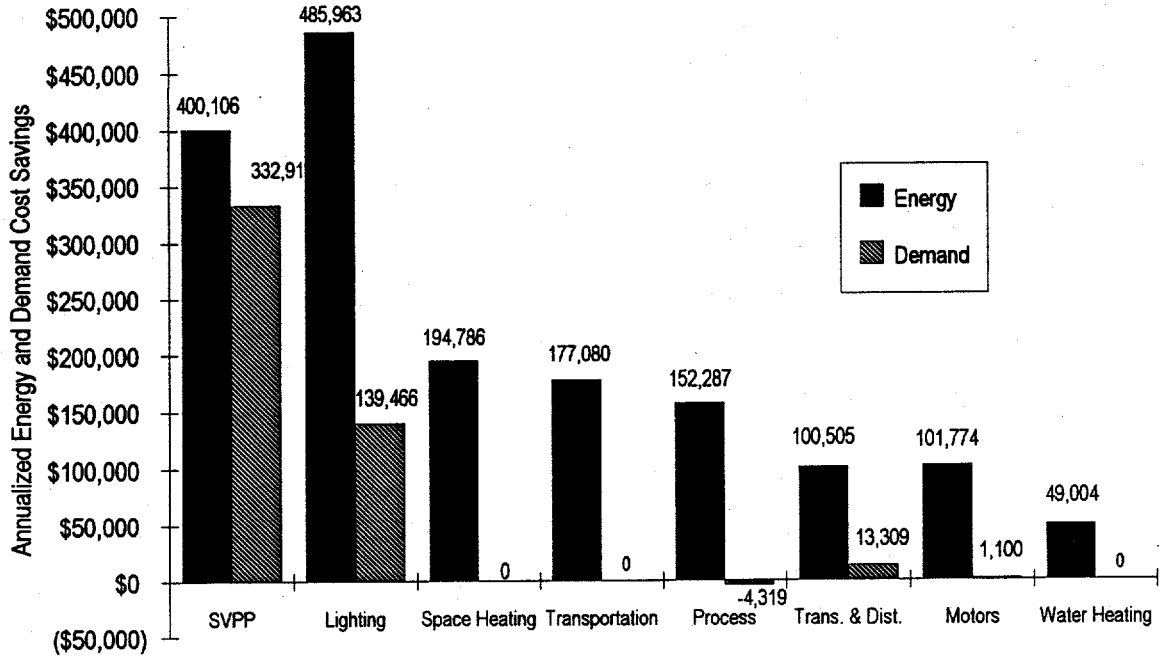

FIGURE 4.3. Annualized Energy and Demand Cost Savings

5.0 IMPLEMENTATION STRATEGY

The purpose of the integrated resource planning process is to develop an analytical and rational approach to reducing energy consumption (and energy costs) at Vandenberg AFB. The implementation step of this process reviews EROs identified in the integrated resource assessment and develops a framework for a long-term energy management plan. When fully developed, this plan will address the types of projects, timing, sources of funding, and other considerations at Vandenberg AFB. In addition, the plan must identify a strategy for negotiating with the electric utility (PG&E) and the gas utility (Southern California Gas Company) to take full advantage of utility incentives offered through promotional and DSM programs.

Discussions with the Vandenberg AFB energy manager, combined with findings and results from other PNL projects at Vandenberg AFB and other federal sites, were used to develop the Extended Energy Project Implementation Structure contained in Appendix B. The only other PNL project at Vandenberg AFB was the economic analysis of the SVPP (Daellenbach et al. 1993b).

The following criteria were used by PNL to select projects:

- financial/cost effectiveness
- technology selection (risk, order of implementation)
- mission considerations
- savings verification requirements
- O&M considerations
- environmental impacts.

The EROs for electricity and fossil fuels should be reviewed and categorized based on the selection criteria and Vandenberg AFB priorities. EROs with a relatively small investment cost and significant savings should be singled out for prompt implementation. These EROs are discussed in Appendix B, Section B.1. EROs with significant Energy Conservation Investment Program (ECIP) potential should be identified (for documenting and submitting) in accordance with ECIP program requirements.

Water conservation and renewable resources are included in EPAct (Public Law 102-486). EPAct and several funding sources provide additional incentives and opportunities beyond energy efficiency technologies. A water conservation opportunity and a discussion on renewable energy opportunities are identified separately in Appendix B, Section B.2.

Additional projects, which are not part of the PNL assessment, are discussed in Appendix B, Section B.3. These suggested projects either take advantage of on-going energy activities at Vandenberg AFB, involve special technologies, or encourage regular reviews of institutional programs. The institutional projects primarily ensure continued installation of energy-efficient technologies, efficient technology replacement of failed equipment, and the most beneficial utility rates. With the exception of institutional programs, special technologies and projects need to be evaluated using the federally-mandated LCC methodology to determine the cost-effectiveness of these additional projects and to be consistent with the PNL assessment.

From the results of the integrated resource assessment, nearly 260 EROs were divided into 10 projects to be implemented over the next 5 years. These EROs are the "winners"; i.e., they possess the largest NPV compared to similar technologies using the same and alternate fuels. Examples of major projects to be initiated immediately at Vandenberg AFB include the following:

- Replace inefficient fluorescent and incandescent lamps, ballasts, and fixtures with high-efficiency fluorescent lamps and electronic ballasts. The combined lighting EROs represent the single greatest efficiency resource at Vandenberg AFB (9,255 MWh and 27.3 MW-mo demand).

- Formulate a plan for operating the SVPP (if a plan has not already been completed). The study by PNL recommends continuing to use the plant for mission-critical launch support, as well as peak shaving during all cost-effective permitted hours.

Other projects to be subsequently implemented include the following:

- Formulate a plan to replace motors with high-efficiency units. Begin plans to immediately replace motors as recommended in Volume 3:

Resource Assessment (Daellenbach et al. 1993a). Develop a system by which any motor that fails will automatically be upgraded to the highest (cost-effective) efficiency.

- Replace distribution transformers as they fail with efficient units as described in Volume 3: Resource Assessment (Daellenbach et al. 1993a). Use amorphous core transformers for capacities lower than 1,000 kVA and improved silicon steel transformers for capacities greater than 1,000 kVA.

Many of these projects will require several years to design, procure, and fully implement. Verification of energy savings should continue for the life of the equipment.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The integrated resource assessment at Vandenberg AFB was a major effort to identify various ways to meet the goals established under Executive Order 12759 (56 FR 16257). The significant conclusions and lessons learned from this work include the following:

- The systematic approach used to identify EROs provides a framework for long-range energy planning to meet mandated energy reduction goals. The projects identified from this analysis can be implemented over a period of several years as funding is available.

- The integrated resource assessment provides accurate, complete, and detailed results that can be used as the basis for prioritizing energy efficiency decisions.

- Substantial energy reduction (7.6%) and cost savings (13.6%) are available at Vandenberg AFB.

- In the future, DSM funding will be available through PG&E, but may be limited to certain efficient technologies. Additional funding sources should be explored for other electric, nonelectric, and fuel-switching projects. Additional funding sources include, but are not limited to, ECIP and shared energy savings.

- The implementation process, although predominately directed toward acquiring energy-efficient technology, must also consider and integrate other issues having potential to affect energy consumption. Examples of other issues include regular reviews of utility rate schedules, energy standards for retrofitted and new construction, and institutional procedures that ensure energy-efficient technologies are installed when ROF occurs.

- EPAct (Public Law 102-486) provides Vandenberg AFB new and expanded opportunities in other energy-related technologies such as water, solar, and other renewables. Further evaluation of these opportunities should occur, following the same LCC methodology (10 CFR 436) as all other EROs evaluated in this assessment.

The major recommendations of this assessment include the following:

- An expanded mission and continued growth are anticipated at Vandenberg AFB beyond the year 2000. These changes will affect the LCC effectiveness of the remaining EROs and may result in the addition of more EROs. Some of the changes that can affect ERO results include new

construction, building demolition and decommissioning, utility rate changes, and ERO implementation. These changes should be evaluated during the planning process—not after installation.

- Significant savings in energy and dollars are available to Vandenberg AFB through the installation of energy-efficient technology. Despite the prospects for ERO savings, significantly more savings (perhaps as much as four times) are possible through improved O&M. When funding is available to invest in an ERO savings opportunity, investing in energy-efficient technology should be compared to investing in maintenance.

- The PNL-developed Facility Energy Decision Screening (FEDS) Level-2 (FEDS-2) software was recently released and is available for use by the Vandenberg AFB energy manager (Dirks and Wrench 1993). The FEDS-2 software is a tool that provides capabilities beyond analyzing the LCC effectiveness of EROs. The FEDS-2 software can be used to quickly and methodically examine many types of proposals (such as shared-energy savings and alternative funding) and new energy savings suggestions ("what if" ideas.) The FEDS-2 software provides consistent and auditable results in accordance with federal regulations. The data collected for the integrated resource assessment can be used to create a functional FEDS-2 input file for Vandenberg AFB.

7.0 REFERENCES

10 CFR 436. 1990. U.S. Department of Energy. "Federal Energy Management and Planning Programs." U.S. Code of Federal Regulations.

56 FR 16257. April 17, 1991. "Federal Energy Management." Federal Register.

59 FR 11463. March 8, 1994. "Energy Efficiency and Water Conservation at Federal Facilities." Federal Register.

Currie, J. W. 1992. Testimony by J. William Currie, Ph.D., Manager, Energy Systems Modernization Office, Pacific Northwest Laboratory, before The Senate Committee on Governmental Affairs, Washington, D.C., 18 February 1992. PNL-SA-20228, Pacific Northwest Laboratory, Richland, Washington.

Daellenbach, K. K., J. E. Dagle, A. L. Dittmer, D. B. Elliott, M. A. Halverson, B. J. Hickman, G. B. Parker, E. E. Richman, and S. A. Shankle. 1993a. Vandenberg Air Force Base Integrated Resource Assessment, Volume 3: Resource Assessment. PNL-8730 Vol. 3, Pacific Northwest Laboratory, Richland, Washington.

Daellenbach, K. K., J. E. Dagle, R. W. Reilly, and S. A. Shankle. 1993b. Economic Analysis of Operating Alternatives for the South Vandenberg Power Plant at Vandenberg Air Force Base, California. PNL-8556, Pacific Northwest Laboratory, Richland, Washington.

Dirks, J. A., and L. E. Wrench. 1993. "Facility Energy Decision Screening (FEDS) Software System." In International Energy and Environmental Congress, CONF-93095-1. August 4-5, 1993, Minneapolis, Minnesota. National Technical Information Service, Springfield, Virginia.

Energy Policy Act of 1992 (EPAct). Public Law 102-486, 106 Stat 2776.

Halverson, M. A., E. E. Richman, J. E. Dagle, B. J. Hickman, K. K. Daellenbach, and G. P. Sullivan. 1993. Vandenberg Air Force Base Integrated Resource Assessment, Volume 2: Baseline Detail. PNL-8730 Vol. 2, Pacific Northwest Laboratory, Richland, Washington.

U.S. Department of Energy (DOE). 1992. Annual Report to Congress on Federal Government Energy Management and Conservation Progress. DOE/CE-0343P, Washington, D.C.

U.S. General Services Administration (GSA). 1989. Summary Report of Real Property Owned by the United States Throughout the World as of September 30, 1989. GSA Public Buildings Service, Office of Governmentwide Real Property Relations, Washington, D.C.

APPENDIX A

LIFE-CYCLE COST METHODOLOGY

APPENDIX A

LIFE-CYCLE COST METHODOLOGY

According to the provisions of 10 CFR 436, federal agencies are required to analyze all potential energy investments using an LCC methodology developed by the National Institute of Standards and Technology (NIST 1992). The NIST LCC methodology calculates all relevant costs of a project and discounts them to a common basis in present dollars. The method then subtracts the project's LCC from a similarly constructed LCC of the baseline. (The baseline is represented by the current conditions or technology.) This difference is the NPV of the action being considered. Actions are cost-effective if the NPV is positive and optimal if the NPV is greater than the NPV of alternative actions. Following this methodology results in minimizing the LCC of energy services at a site.

This economic analysis is central to the FEMP model approach for federal energy efficiency. The model approach uses the FEDS software system to develop a fuel-neutral assessment of facilities to identify and quantify energy efficiency resources, supply alternatives, and fuel-switching opportunities (Dirks and Wrench 1993).

All EROs identified by the FEDS assessment and described in Volume 3: Resource Assessment (Daellenbach et al. 1993) are therefore subjected to the LCC economic analysis to determine their cost-effectiveness. The purpose of the FEDS assessment is to identify the facility energy efficiency resource alternatives available to decision makers. The economic analysis provides an estimate of the installed cost and energy savings of the cost-effective resource available at a facility, using the most current and realistic assumptions possible. Individual projects and actions considered for implementation should be examined and analyzed more thoroughly at a project level prior to design and implementation.

Under the NIST methodology, energy prices are escalated and costs and benefits are discounted using factors taken from the current edition of "Energy Prices and Discount Factors for Life-Cycle Cost Analysis 1993" (NIST 1992). Costs and benefits are analyzed over a 25-year period, reflecting the average expected remaining life of a typical building. Other key assumptions in the methodology are as follows:

- Prices for all goods and services (e.g., installed cost of a technology) vary at the same rate as the inflation rate; therefore, the "real" rate of inflation is zero.

- Energy or fuel prices vary at a rate different than that of the inflation rate. NIST reports the value by which the energy prices vary from the real rate of inflation (the escalation rate).

- All costs and benefits are discounted using the current federal discount rate (4.0% real for calendar year 1993).

- All EROs are analyzed for a 25-year period, which does not mean that a 25-year life is assumed for all installed equipment. Actual estimates of equipment life are used, and the costs of replacing worn out equipment over a 25-year period are incorporated. The 25-year analysis period also does not mean that all streams of savings from EROs are assumed to endure 25 years—many are assumed to disappear as the existing equipment is replaced with more efficient equipment as part of the baseline.

- The analysis assumes that upfront, unconstrained federal financing (at the federal discount rate) is available for all potential energy efficiency improvements and actions.

The last assumption, unconstrained (unlimited) federal financing, is incorporated into the LCC analysis to determine the total cost-effective energy efficiency resource at a site. Therefore, the analysis (under the unconstrained funding assumption) results in a menu of all identified energy project opportunities whose benefits exceed their costs.

Because of constraints on available funding to implement these projects, a method is needed to prioritize the projects. Therefore, a savings-to-investment ratio (SIR) is calculated to rank the order of projects, starting with the project with the highest SIR. This ranking allows available capital

to be allocated to those cost-effective projects in an order that results in the greatest savings per dollar of investment.

For most agencies or facilities, the entire list of cost-effective projects from the LCC analysis is significant and cannot be financed from a single source. Rather, all available funding sources need to be determined. Funding sources include federal funds (military construction [MILCON], ECIP, Federal Energy Efficiency Fund); utility financing including utility-offered rebates or other financial assistance; and energy services industry-financed projects. Each of these funding sources has its own requirements and costs; therefore, the cost-effectiveness of individual projects needs to be evaluated using the LCC analysis adjusted for each potential funding source's costs and constraints.

Many assumptions, in addition to those listed above, are required in the course of a FEDS assessment. In every case, the analysis team attempts to make the most realistic and defensible assumption. Where uncertainty exists, the team attempts to err on the side of conservatism. Therefore, the resulting estimate of the total cost-effective energy efficiency resource is a minimum estimate of the total potential resource, given the above assumptions. A more exact estimate and/or the development and design of projects may require a detailed facility audit. Such a detailed audit is beyond the scope of a FEDS assessment.

REFERENCES

10 CFR Part 436. 1990. U.S. Department of Energy. "Federal Energy Management and Planning Programs." U.S. Code of Federal Regulations.

Daellenbach, K. K., J. E. Dagle, A. L. Dittmer, D. B. Elliott, M. A. Halverson, B. J. Hickman, G. B. Parker, E. E. Richman, and S. A. Shankle. 1993. Vandenberg Air Force Base Integrated Resource Assessment, Volume 3: Resource Assessment. PNL-8730 Vol. 3, Pacific Northwest Laboratory, Richland, Washington.

Dirks, J. A., and L. E. Wrench. 1993. "Facility Energy Decision Screening (FEDS) Software System." In International Energy and Environmental Congress, CONF-930895-1. August 4-5, 1993, Minneapolis, Minnesota. National Technical Information Service, Springfield, Virginia.

National Institute of Standards and Technology (NIST). 1992. Energy Prices and Discount Factors for Life-Cycle Cost Analysis 1993. NIST Handbook 135, National Technical Information Service, Springfield, Virginia.

APPENDIX B

EXTENDED ENERGY PROJECT IMPLEMENTATION STRUCTURE

APPENDIX B

EXTENDED ENERGY PROJECT IMPLEMENTATION STRUCTURE

Suggested projects for Vandenberg AFB are discussed below. The EROs evaluated by PNL in this assessment are contained in Section B.1, B.2, and B.4. Each evaluated ERO is followed by a table showing a summary of the evaluation results. Additional projects, which were not part of the PNL assessment but are part of good institutional plans, are discussed in Section B.3. Two LCC parameters are listed to help determine possible funding sources--SIR and simple payback. The SIR is equal to the PV of total savings of an ERO divided by the PV of the installed cost of that ERO. Any ERO with an SIR greater than one indicates that the savings outweigh the costs. Simple payback is the installed cost divided by the sum of the first year energy and demand savings plus any nonfuel costs/savings (O&M and replacement costs). Because the ROF options occur over time, no single value for the installed cost exists and a simple payback cannot be calculated.

B.1 TECHNOLOGIES AND FUELS

B.1.1 Heating - Nonresidential Boilers ERO

Replace older, inefficient boiler systems with higher efficiency models. This project also considered potential fuel switches (to or from gas or oil in buildings with these fuels available), automatic blowdowns, boiler tune-ups, feedwater economizers, and vent dampers. Table B.1 shows a summary of the evaluation results for boiler replacement.

B.1.2 Residential Building Envelope ERO

Evaluate typical environmentally controlled residential building envelope considerations for energy-use reduction, such as adding insulation to walls and/or attic and weather stripping. Table B.2 shows a summary of the evaluation results for an environmentally controlled building envelope.

TABLE B.1. Summary of Evaluation Results for Boiler Replacement

	RI[a]
First Year Energy Savings (MBtu)	10,383
Annualized Energy Savings ($/yr)	69,999
PV of Installed Cost (1992$)	224,951
First Year O&M Savings (1992$)	0
NPV of Project (1992$)	845,373
SIR	4.76
Simple Payback (yr)	3.77

(a) RI = replace immediately

TABLE B.2. Summary of Evaluation Results for Environmentally Controlled Building Envelope

	Attic Insulation	Weatherization
First Year Energy Savings (MBtu)	21,497	3,308
Annualized Energy Savings ($/yr)	101,645	23,141
PV of Installed Cost (1992$)	1,442,402	78,433
First Year O&M Savings (1992$)	0	0
NPV of Project (1992$)	324,922	261,207
SIR	1.23	4.33
Simple Payback (yr)	14.73	4.35

B.1.3 Domestic Hot Water ERO

Wrap additional insulation around existing gas water heater tanks to reduce standby losses. Table B.3 shows a summary of the evaluation results for additional insulation around water heater tanks.

TABLE B.3. Summary of Evaluation Results for Additional Insulation Around Water Heater Tanks

	Residential	Commercial
First Year Energy Savings (MBtu)	4,859	611
Annualized Energy Savings ($/yr)	27,056	3,402
PV of Installed Cost (1992$)	120,499	15,156
First Year O&M Savings (1992$)	0	0
NPV of Project (1992$)	219,844	27,636
SIR	2.82	2.82
Simple Payback (yr)	4.45	4.46

B.1.4 Interior Lighting ERO

Retrofit existing fluorescent and incandescent fixtures with high-efficiency fluorescent lamps and electronic ballasts. Building lighting efficiency can be improved 21% by this retrofit. A survey of buildings determined the potential for savings. Table B.4 shows a summary of the evaluation results for interior lighting retrofits.

TABLE B.4. Summary of Evaluation Results for Interior Lighting Retrofits

	Residential	Commercial
First Year Energy Savings (kWh)	3,097,430	6,157,344
First Year Demand Savings (kW-mo)	10,176	17,102
Annualized Net Energy Savings (1992$)	159,461	326,503
Annualized Net Demand Savings (1992$)	52,028	87,437
PV of Installed Cost (1992$)	1,970,296	4,742,471
PV of O&M Savings (1992$)	1,543,116	3,528,224
NPV of Project (1992$)	2,676,790	4,861,048
SIR	2.36	2.03
Simple Payback (yr)	6.21	7.23

B.1.5 High-Efficiency Motor ERO

Replace existing single-speed standard-efficiency motors with high-efficiency motors. These motors are typically used for fan and pump applications. High-efficiency motors are typically not considered for motors below 1 hp, but this may soon change. A standard operating procedure for replacement on failure of all existing motors with high-efficiency motors should be developed. Table B.5 shows a summary of the evaluation results for installing high-efficiency motors.

TABLE B.5. Summary of Evaluation Results for Installing High-Efficiency Motors

	RI	ROF
First Year Energy Savings (kWh)	1,974,854	93,034
First Year Billable Demand Savings (kW-mo)	217	0
Annualized Net Energy Savings (1992$)	98,563	3,212
Annualized Net Demand Savings (1992$)	-81,817	-35,964
PV of Installed Cost (1992$)	220,669	49,567
First Year O&M Savings (1992$)	0	0
NPV of Project (1992$)	1,354,536	37,644
SIR	7.14	1.76
Simple Payback (yr)	2.05	NA

B.1.6 Transmission and Distribution System ERO

The purpose of this project was twofold. First, the existing T&D system was examined for implementing LCC-effective energy efficiency upgrades. Second, a recommendation was made to establish a plan to ensure T&D equipment replaced on failure, or for environmental reasons, is the most cost-effective based on LCC analyses. The T&D system was examined for immediate and ROF energy efficiency opportunities. There were no cost-effective options for immediate replacement of T&D systems. Table B.6 shows a summary of the evaluation results for replacing T&D systems.

TABLE B.6. Summary of Evaluation Results for Replacing Transmission and Distribution Systems

	ROF
First Year Energy Savings (kWh)	3,049,796
Annualized Net Energy Savings (1992$)	100,505
Annualized Net Demand Savings (1992$)	13,309
PV of Installed Cost (1992$)	6,727,565
First Year O&M Savings (1992$)	0
NPV of Project (1992$)	737,205
SIR	1.11
Simple Payback (yr)	NA

B.1.7 Transportation ERO

Convert existing gas- and diesel-fueled vehicles to operate on compressed natural gas. These nontactical vehicles consist primarily of cars, pickups, vans, trucks, buses, station wagons, and forklifts. A plan should be implemented to purchase compressed-natural-gas vehicles as the existing vehicles are replaced over time. Table B.7 shows a summary of the evaluation results for converting gas- and diesel-fueled vehicles.

TABLE B.7. Summary of Evaluation Results for Converting Gas- and Diesel-Fueled Vehicles

	RI	ROF
First Year Energy Savings (MBtu)	20,406	4
Annualized Net Energy Savings (1992$)	177,053	27
PV of Installed Cost (1992$)	886,000	6,398
PV of O&M Savings (1992$)	2,972,504	14,581
NPV of Project (1992$)	3,531,020	2,034
SIR	4.99	1.32
Simple Payback (yr)	3.38	NA

B.1.8 Process Loads ERO

Almost 40% of the total energy consumption at Vandenberg AFB is estimated to be for mission-critical activities directly related to missile and rocket launches. This "process energy" encompasses actual vehicle-related activities as well as data gathering, processing, and telemetry in support of launches. The primary energy for at least 150 facilities is included in the process category. Process energy savings for SLC-4 were evaluated. The results of the process load evaluation are shown in Table B.8. To determine the full potential for process energy savings, investigations of all space launch complexes and process facilities should be undertaken.

TABLE B.8. Summary of Evaluation Results for Process Loads

	Totals
First Year Electric Energy Savings (kWh)	1,378,694
First Year Fossil Energy Savings (MBtu)	4,750
Annualized Net Energy Savings (1992$)	157,287
Annualized Net Demand Savings (1992$)	-7,316
PV of Installed Cost (1992$)	1,855,800
PV of O&M Savings (1992$)	950,515
NPV of Project (1992$)	1,558,883
SIR	1.84
Simple Payback (yr)	8.00

B.2 WATER AND RENEWABLES

B.2.1 Water Conservation ERO

Replace existing shower heads (in family housing) with high-efficiency low-flow shower heads. Existing water closets should be replaced with high-efficiency low-water consumption water closets such as a tank pressurization type. Energy savings are realized from reduced water heating, pumping, and water treatment. This project qualifies for special ECIP funding considerations under EPAct (Public Law 102-486). Table B.9 shows a summary of

the results of the evaluation on replacing existing shower heads with low-flow shower heads.

TABLE B.9. Summary of Evaluation Results for Installing Low-Flow Shower Heads

	Total
First Year Energy Savings (MBtu)	2,869
Annualized Net Energy Savings (1992$)	20,033
PV of Installed Cost (1992$)	38,260
First Year O&M Savings (1992$)	0
NPV of Project (1992$)	222,702
SIR	6.82
Simple Payback (yr)	2.87

B.2.2 Renewable Energy ERO

The potential for renewable energy, including landfill methane recovery, solar, geothermal, and wind, was investigated.

B.3 INSTITUTIONAL ENERGY PLANS

B.3.1 High-Efficiency Motor Replacement ERO

Develop a standard operating procedure for replacement on failure of all existing motors with high-efficiency motors. The procedure is necessary to ensure high-efficiency motors replace standard, low-efficiency motors.

B.3.2 Energy Standards for New Construction ERO

Develop installation-wide standards to ensure any new construction is as energy-efficient as practical. The standards will utilize the latest guidelines/standards from DOE, DoD, the U.S. Army Corps of Engineers, and other sources.

B.3.3 Energy Rates and Structure Evaluation ERO

Evaluate the base's utility rate structures for both gas and electricity every 2 years (minimum recommended) to determine if they are best suited to satisfy mission requirements. The electrical rates will include time-of-day kilowatt per hour charges and peak load charges. Future evaluations should include the possibility of "wheeling" energy. ("Wheeling" is buying energy from another utility and using the local utility's distribution system to transport the energy to the base.)

B.3.4 Fuel Switch or More Efficient Equipment ERO

Evaluate the various sources of fuel every 2 years to determine if better choices exist. Fuel-switching as well as upgrading to more energy-efficient equipment will be considered.

B.3.5 Open Dialogue With Natural Gas Suppliers ERO

Continue coordinating with gas suppliers to stay abreast of existing and future incentives with regard to natural gas. This effort includes upgrading equipment to more efficient models, fuel-switching, and extending distribution systems to new areas.

B.3.6 Competitively Purchased Electricity ERO

Investigate the opportunities available to minimize the cost of purchased electricity in accordance with anticipated federal legislation requiring open access (often referred to as "wheeling") to suppliers of electrical energy. Open access to suppliers of electrical energy could occur as early as FY96. Open access to gas suppliers currently exists under Federal Energy Regulatory Commission (FERC) Ruling 636, which deregulated the gas distribution system (FERC 1992). At this time, project activity involves monitoring federal legislative activities associated with open access to suppliers of electrical energy.

B.3.7 Gas, Sewer, and Water Privatization ERO

Investigate the economic feasibility of privatizing sewer, water, and natural gas distribution systems. An independent government estimate must be prepared to determine the costs/benefits.

B.3.8 Transmission and Distribution ERO

The potential for growth will mean new and expanded T&D systems. Evaluate T&D systems for energy savings opportunities, including consolidation of substations, voltage reductions, and system redistribution.

B.3.9 Appliance Replacement ERO

Conduct an economic analysis to determine the most LCC-effective appliance for family housing replacements. Install high-efficiency refrigerators. Gas-fired refrigerators are one type of refrigerator to be investigated. Install clothes dryer connections that utilize the most efficient fuel, with electricity and natural gas investigated as a minimum. Install high-efficiency dishwashers. Evaluate gas-fired ranges for LCC.

B.3.10 Propane Plant Addition ERO

Evaluate propane air plant to provide backup for natural gas supply and any interruptable fuel rates that may apply to Vandenberg AFB.

B.4 OPERATIONS AND MAINTENANCE

B.4.1 South Vandenberg Power Plant Operation ERO

Develop and implement a plan to operate the SVPP in the most efficient and cost-effective manner. According to PNL's evaluation, the best operating scenario is to continue to support mission-critical launch activities as well as peak shaving during all cost-effective, permitted periods (Daellenbach et al. 1993). Table B.10 shows a summary of the evaluation results for the SVPP operations plan. (Life-cycle costing parameters were not calculated for this ERO because there is no installed cost. In theory, the SIR is infinite and the payback is zero.)

TABLE B.10. Summary of Evaluation Results for SVPP Operations Plan

	Total
First Year Energy Savings (MBtu)	-234,440
First Year Demand Savings (kW-mo)	51,300
Annualized Net Energy Savings (1992$)	400,106
Annualized Net Demand Savings (1992$)	332,913
PV of Installed Cost (1992$)	NA
PV of O&M Savings (1992$)	-59,314
NPV of Project (1992$)	10,699,027

B.5 REFERENCES

Daellenbach, K. K., J. E. Dagle, R. W. Reilly, and S. A. Shankle. 1993. Economic Analysis of Operating Alternatives for the South Vandenberg Power Plant at Vandenberg Air Force Base, California. PNL-8556, Pacific Northwest Laboratory, Richland, Washington.

Energy Policy Act of 1992 (EPAct). Public Law 102-486, 106 Stat 2776.

Federal Energy Regulatory Commission (FERC). April 8, 1992. "Pipeline Service Obligation and Revision to Regulations Governing Self-Implementing Transportation and Regulation of Natural Gas Pipeline After Well Head Decontrol." Docket No. RM 91-11-000, Federal Energy Guidelines, par. 3939, FERC Statutes and Regulations, Washington, D.C.

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