PNL-9065 Vol. 1
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Fort Irwin National Training Center Integrated Resource Assessment

Volume 1: Executive Summary

D. L. Hadley, Project Manager
J. M. Keller
E. E. Richman
D. J. Stucky

May 1995

Prepared for
the U.S. Department of Energy
Federal Energy Management Program
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

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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 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. Even where meters are available on individual buildings or family housing units, the meters 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 selection of suboptimal projects that prevent the site from achieving full life-cycle cost savings.

The U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) has been tasked by the U.S. Army Forces Command (FORSCOM) to identify, evaluate, and acquire all cost-effective energy projects at selected federal facilities. Pacific Northwest Laboratory (PNL)[a] is assisting FEMP in this effort. This is part of a model program that PNL has developed to provide 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), and 2) evaluates the numerous options for retrofit or installation of new technology that will result in the selection of 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.

This report provides the results of the fossil fuel and electric energy resource opportunity (ERO) assessments performed by PNL at the U.S. Army's Forces Command (FORSCOM) facility, Fort Irwin National Training Center, located near Barstow, California--one of Southern California Edison's primary federal customers. This is a companion report to Volume 2: *Baseline Detail* (Richman et al. 1994) and Volume 3: *Sitewide Energy Project Identification for Buildings and Facilities* (Keller et al. 1995).

The results of the analyses of EROs are presented in 19 common energy end-use categories (e.g., boilers and furnaces, service hot water, and building lighting).

(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

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 there is enormous energy and dollar savings potential 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. The Energy Policy Act of 1993, as amended by Executive Order 12902, establishes a goal for all federal agencies to reduce energy consumption by 30% by the year 2005, relative to the agency's 1985 energy use. To assist federal agencies in meeting this target, the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) has been tasked by the U.S. Army Forces Command (FORSCOM) to identify, evaluate, and acquire all cost-effective energy projects at selected federal facilities. Pacific Northwest Laboratory (PNL) is assisting FEMP in this effort.

This report provides the results of the fossil fuel and electric energy resource opportunity (ERO) assessments performed by PNL at the U.S. Army Forces Command (FORSCOM), Fort Irwin National Training Center, located near Barstow, California--one of Southern California's major federal facilities. This is a companion report to Volume 2: *Baseline Detail* (Richman et al. 1994) and Volume 3: *Sitewide Energy Project Identification for Buildings and Facilities* (Keller et al. 1995).

The Fort Irwin analysis made use of the Facility Energy Decision Screening (FEDS) software. The FEDS software is designed to identify, characterize, and assess individual energy projects. At this point in the software development, the FEDS software analyzes most major building end uses (heating, cooling, lighting, envelope insulation, and service hot water), including their interactive effects (e.g., the effect a lighting technology has on heating and cooling loads), providing specific cost, energy (and demand) charges, and life-cycle cost information, by cost-effective technology. The remaining EROs (motors, transmission and distribution, vehicles, etc.) are analyzed using hand calculation (hereafter referred to as "manual") methods.

The results of the FEDS analysis at Fort Irwin were used to identify specific energy efficiency improvement projects. These energy projects were an aggregation of several energy efficiency technology improvements bundled together but applied to a particular building or set of buildings with the same general characteristics, such as age and/or function. The advantage of bundling individual EROs is that it is possible to include some measures that by themselves would not be economical, and therefore not implemented.

Within each individual building energy project, the typical EROs usually involved lighting retrofits, envelope upgrade measures, hot water conservation measures, and HVAC system improvements. Table S.1 lists the top energy conservation projects at Fort Irwin, ranked by net savings of the combined EROs for that building set.

Table S.1. Summary of the Top 10 Building Energy Projects at Fort Irwin

Building Set	SIR	Annual Energy Saving (MBtu)	Annual Demand Savings (kW)	Value of Energy Savings	Value of Demand Savings	Present Value of Installed Cost Savings	Present Value of Energy and Demand Savings	Net Savings
FH DUPLEX 01	3.5	11353	2462	$136,150	$69,627	$1,107,932	$3,702,924	$2,619,960
FH DETACHED 01	5.0	4639	1899	$63,832	$30,029	$598,269	$2,868,276	$2,246,378
ADMINISTRATION 09	3.3	3709	254	$72,594	$27,017	$752,207	$2,468,683	$1,933,705
FH 3 OR MORE 02	2.6	14425	2524	$178,774	$159,247	$876,083	$2,199,434	$1,631,549
ADMINISTRATION 03	3.4	2425	137	$45,248	$14,462	$342,290	$1,175,987	$1,106,009
SHOPS 04	13.3	388	30	$7,602	$3,085	$85,401	$1,134,504	$1,062,354
FH DUPLEX 03	2.6	11303	46	$69,987	$4,687	$488,746	$1,290,527	$1,010,499
RECREATION 02	14.6	96	5	$1,552	$441	$68,076	$991,341	$934,389
FH 3 OR MORE 03	2.9	4835	54	$40,886	$5,750	$306,248	$894,407	$822,314
SCHOOL/TRAINING	7.7	924	81	$19,365	$8,614	$91,388	$701,634	$742,742

Acknowledgments

The authors gratefully acknowledge the assistance of several people associated with Fort Irwin Operations that provided us with detailed and timely information that increased the value and usefulness of this analysis. While it is not possible to identify all those who provided assistance, we would like to thank the following individuals who provided helpful support: Rene Quinones, Linda Osborne, Greg Williams, Orvy Dahl, Ben Rodarte, LaSandra Miller, and Ed Rojas.

In addition, the authors thank Randy Wahlstrom, Kate McMordie, and Steve Parker, all of the Pacific Northwest Laboratory, for their assistance in the collection of data used in this document, and for the conscientious, team-oriented, and high-quality assistance they brought to the Fort Irwin NTC assessment. The efforts of our editor, Dave Payson, are also gratefully acknowledged.

Finally, the authors sincerely acknowledge the support of Mr. Adrian Gillespie of the U.S. Army Forces Command, without whose progressive attitude towards energy issues and his enthusiastic endorsement of energy efficiency at Fort Irwin, this work would not have been possible.

Don Hadley

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Abbreviations and Acronyms

AAFES	Army/Air Force Exchange Service
A/C	air conditioning
AHU	air-handling unit
ASD	adjustable speed drive
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
BLCC	Building Life-Cycle Cost Program
Btu	British thermal unit
CBECS	Commercial Building Energy Consumption Survey
CF	compact fluorescent
d	day
DEH	Directorate of Engineering and Housing
DEIS	Defense Energy Information System
DFSC	Defense Fuel Supply Center
DHW	domestic hot water
DOE	Department of Energy
DoD	Department of Defense
DOS	disk operating system
DSM	demand-side management
EE	energy efficient
EEF	energy efficient ballast
EEM	energy efficient motor
EIA	Energy Information Administration
ELC	electronic ballast
EMCS	energy management control system
EPA	Environmental Protection Agency
ERO	energy resource opportunity
EUI	energy-use intensity
FEMP	Federal Energy Management Program
FO2	fuel oil No. 2
FORSCOM	Forces Command
g	gram
gal	gallon
h	hour
hp	horsepower
HPS	high pressure sodium
HTHW	high temperature hot water
HVAC	heating, ventilation, and air conditioning
Hz	Hertz
IES	Illuminating Engineering Society of North America
IRA	Integrated Resource Assessment
kBtu	thousand British Thermal Unit
kcf	thousand cubic feet
kVA	kilovolt-amperes
KVAR	reactive demand, kilovolt-amperes

kW	kilowatt
kWh	kilowatt-hour
LADWP	Los Angeles Department of Water and Power
lb	pound
LCC	life-cycle cost
LED	light emitting diode
LPS	low pressure sodium
LST	local standard time
LTSM	Lighting Technology Screening Matrix
M	million
mo	month
MBtu	million British thermal unit
MEL	Mobile Energy Laboratory
MH	metal halide
MILCON/ECIP	Army Energy and Conservation Investment Program
MW	megawatt
MWh	megawatt-hour
NBS	National Bureau of Standards
NG	natural gas or National Guard
NIST	National Institute of Standards and Technology
NPV	net present value
NTC	National Training Center
O&M	operations and maintenance
°F	degrees Fahrenheit
PCBs	polychlorinated biphenyls
PCF	permanent compact fluorescent
PG&E	Pacific Gas and Electric Company
PNL	Pacific Northwest Laboratory
psi	pounds per square inch
PV	present value
PX	post exchange
RECS	Residential Energy Consumption Survey
REF	parabolic reflector
RO	reverse osmosis
ROI	return on investment
RPL	real property list
rpm	revolutions per minute
SCE	Southern California Edison Company
SIR	savings to investment ratio
V	volt
VI	value index
W	watt
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 of energy 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). Furthermore, since about 84% of the total Army energy allotment is consumed in buildings (U.S. Army Corps of Engineers 1982), there is a renewed interest in identifying the most energy-efficient methods of operating these facilities.

Evaluations (completed and ongoing) by Pacific Northwest Laboratory (PNL) at over 50 federal installations indicate that there is an enormous energy and dollar savings potential within the federal sector. Evidence suggests that 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 would be applied toward the retrofit and replacement of 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 1992), as amended by Executive Order 12902, federal agencies have set a target by 2005 of a 30% reduction in federal facility energy use (from 1985 levels), and a 20% industrial process efficiency improvement (1990 baseline). This act requires the purchase of energy-consuming goods or products that are the most life-cycle cost-effective. Other legislation affecting energy conservation goals in the federal sector include the Life-Cycle Cost (LCC) method and procedures of 10 CFR 436.

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. It 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 demand-side management (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. Sources of funding for implementation of these energy efficiency improvements specific to Fort Irwin include the Department of Army's Energy and Conservation Investment Program (MILCON/ECIP) and the Federal Energy Management Program (FEMP). Another potential source of funds are Southern California Edison DSM programs and the ENVEST-sponsored comprehensive energy efficiency programs.

Some of the most difficult questions that a federal site has to address in reducing its energy consumption in a cost-effective manner include where the energy is being used and what technologies could be employed to decrease the energy use. The Department of Energy's FEMP, supported by PNL, has been tasked by the U.S. Army Forces Command (FORSCOM) to identify, evaluate, and acquire all cost-effective energy projects at Fort Irwin National Training Center (NTC). The model program developed by FEMP constitutes a systematic approach to evaluating energy opportunities that 1) identifies the building groups and end uses that use the most energy (not just have the greatest energy-use intensity), and 2) evaluates the numerous options for retrofit or installation of new technology that will result in the selection of the most cost-effective technologies. In essence, this model program provides the Fort Irwin energy manager with a roadmap 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.

This report provides a summary of the baseline of energy use information found in Volume 2: *Baseline Detail* (Richman et al. 1994) and of the assessment of energy resource opportunities found in Volume 3: *Resource Assessment* (Keller et al. 1995). The Fort Irwin NTC installation is characterized in Section 2. A baseline of energy use is found in Section 3. The analytical approach for determining energy resource opportunities (EROs) is described in Section 4, with a summary of resource assessment results in Section 4.1. Section 5 describes the strategy for implementation of EROs, and the conclusions and recommendations are found in Section 6. References are listed in Section 7, and the life-cycle cost methodology and other supporting information are provided in the appendixes.

2.0 Site Characteristics

Fort Irwin is a roughly 1,000-square-mile U.S. Army FORSCOM facility situated in the Mojave Desert approximately 37 miles northeast of Barstow, California, and south of Death Valley. The main cantonment is located near the southeastern portion of Fort Irwin. The primary mission at Fort Irwin is the operation of the NTC.

The climate at Fort Irwin is classified as "high desert" with an average rainfall of 2.5 inches annually, mainly between December and February. Summer maximum temperatures are around 104°F, and winter minimum temperatures are around 29°F. Annual heating and cooling degree days (base 65°F) are generally equivalent to each other at 2,547 and 2,272, respectively. Typical monthly maximum, minimum and dew point temperatures are shown in Figure 2.1.

2.1 Residential and Commercial Buildings

Roughly 842 commercial buildings (not including schools) with an area of 3,439,606 ft^2 are reported in the Fort Irwin Real Property Data Base (RPL). There are an additional 732 housing buildings (1636 units - not including General's Quarters) with a reported area of 2,961,830 ft^2, for a total building area of 6,401,436 ft^2.

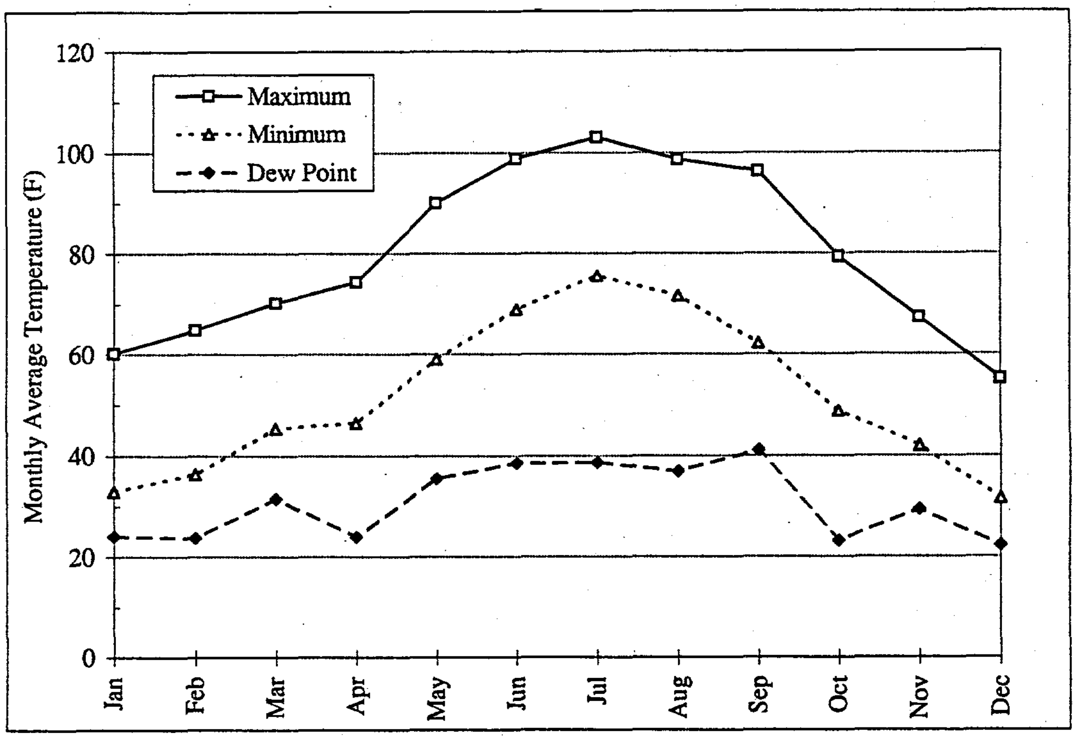

Figure 2.1. Monthly Average Maximum, Minimum, and Dew Point Temperatures Representative of Fort Irwin

Considerable expansion is occurring at Fort Irwin. A new 172- unit housing area was completed in 1993, a 220-unit family housing area is planned for completion in FY96, and several new modular office buildings have recently been added. The buildings at Fort Irwin have been divided into 98 unique building types, based on common characteristics such as function, fuel use, age, construction, etc. Appendix A lists the building types, along with the number of buildings, average age, and total floor area.

Family housing is the single largest category by square footage at Fort Irwin, followed by barracks, administration, motor pools, warehouses, manufacture administration, and general shops. These building types account for over 80% of the total building stock at Fort Irwin. Because of the different energy use intensities (EUIs) in each building type, building types with greater square footage do not necessarily consume more energy.

Commercial buildings are a mix of older wood frame and newer stone/brick construction, with some metal frame and curtain wall construction. Family housing is primarily wood frame construction with varying levels of insulation in the walls or ceilings.

2.2 Water and Sewer Service

Water is provided to Fort Irwin by eleven operating wells and six booster pumps. Eight of the wells are located in and around the main commercial area. The remaining three wells are to the northeast toward the Bicycle Lake Basin. The aggregate capacity of the well pumps is reported to be 4,595 gpm with an aggregated load of 1,040 horsepower. Booster pumps are also in operation with each of the well systems at a total effective load of approximately 1,050 horsepower.

In addition to the well and booster pump system, demineralized water is produced for use at Fort Irwin. This is supplied to all occupied facilities through a separate distribution system. Demineralization is accomplished at the Reverse Osmosis (RO) Plant. The current major aggregate load of the equipment at the RO plant is approximately 255 horsepower.

Sewage treatment for Fort Irwin is provided by an onsite system that treats sewage for the central Fort Irwin facilities and for family housing. The current major aggregate load of the equipment at the sewage treatment plant is approximately 210 horsepower.

2.3 Street and Parking Lot Lighting

Exterior street and parking lot lighting at Fort Irwin comprises a variety of lighting types and capacities including high pressure sodium, mercury vapor, and metal halide. Accurate records of quantities and capacities were not available from Fort sources. A manual lighting count was completed that included all street and parking lot lights in and around the commercial, family housing, and nearby field station areas. Also included in the count were the perimeter lights at the ordnance storage area. This count, along with some lamp procurement information collected at the Fort, was used to estimate street and lot lighting energy consumption.

The total streetlighting demand was calculated to be 483 kW. Assuming a conservative 10 hours of operation per day (many will operate longer but some are only used during specific activity), this is equivalent to a total of 1,764 MWh per year.

3.0 Energy Use Baseline

Energy sources used by Fort Irwin include electricity, propane, and vehicle fuel. Fuel oil is used in small quantities primarily for backup generator systems and is not considered in this assessment. Table 3.1 shows a summation of the sample yearly energy consumption and cost at Fort Irwin for all facilities including family housing. For each energy type, the yearly total is shown in units appropriate to the energy as well as a common unit as a basis of comparison. These aggregations of various billing consumption amounts are based on the best available data gathered from 1991 through April 1993 and are considered typical of normal Fort Irwin operational energy consumption.

3.1 Electric Supply Source Description

Electricity is supplied to Fort Irwin by Southern California Edison (SCE) and delivered to the Tiefort Terminal Station via a 115-kV transmission line. A sub-transmission line rated at 34.5-kV connects this station to the Fort Irwin substations. Fort Irwin is supplied under rate schedule TOU-8, with an additional incremental sales rate agreement covering additional electricity usage above pre-set limits. The rate structure applicable to Fort Irwin (as of July 1992) is shown in Table 3.2.

Monthly utility meter readings for June 1992 through May 1993 are shown graphically in Figure 3.1. These represent the utility billing records used as the sample year baseline consumption.

3.1.1 End-Use Breakdown

Table 3.3 shows the overall split of electric consumption by end-use sectors. This accounts for nearly 100% of the total use for the sample base year at Fort Irwin. The biggest, single electrical energy consumers are buildings (81% of base total). The electrical consumption by end use within building sector is shown in Figure 3.2.

Table 3.1. Yearly Energy Consumption and Energy Cost at Fort Irwin

Energy Type	Yearly Total	Yearly Total (MBtu)[a]	Percent of Total	Yearly Total (1993$)	Percent of Total
Electricity	72,870 MWh	248,705[b]	18.7	6,271,513	52.8
Propane	2,369,487 gal	225,101[c]	16.9	1,120,293	9.5
Gasoline	446,098 gal	55,760[d]	4.2	370,261	3.1
Diesel	3,718,042 gal	516,810[e]	38.9	2,491,088	21.0
JP-4	770,500 gal	97,850[f]	7.4	577,875	4.9
JP-8	1,367,750 gal	184,650[g]	13.9	1,025,813	8.7
Totals		1,328,876	100.0	11,856,843	100.0

(a) 1 MBtu = 1,000,000 Btu.
(b) 3,413 Btu/kWh.
(c) 0.095 MBtu/gal.
(d) 0.125 MBtu/gal.
(e) 0.139 MBtu/gal.
(f) 0.127 MBtu/gal.
(g) 0.135 MBtu/gal.

Table 3.2. Fort Irwin Electrical Rate Structure (July 1992)

Rate Periods	Summer	Winter
	(first Sunday in June - first Sunday in October)	(first Sunday in October - first Sunday in June)
Peak	12:00 noon to 6:00 PM (M-F)	NA
Mid-Peak	8:00 AM to 12:00 noon (M-F) 6:00 PM to 11:00 PM (M-F)	8:00 AM to 9:00 PM (M-F)
Off-Peak	All other hours not listed plus all day on weekends and holidays	
Super Off-Peak	NA	12:00 midnight to 6:00 PM

Base Rates:		
Charge	Summer	Winter
Demand Charges (per kW) Non-Time Related: Maximum Peak Demand (not less than 50% of previous 11 months	$3.15	$3.15
Time Related: Maximum Peak Period Demand Maximum Mid-Peak Period Demand Maximum Off-Peak Period Demand	 $15.75 $2.35 $0.00	 NA $0.00 $0.00
Energy Charges (per kWh) Peak Period Mid-Peak Period Off-Peak Period	 $0.13752 $0.06517 $0.04077	 NA $0.07688 $0.04335
Power Factor Adjustment (per kVAR)	$0.25	$0.25
Peak Period Rate Limiter (per kWh)	$1.07244	NA
Peak Period Ave. Rate Limiter (per kWh)	$0.17759	NA
Customer Charge (per meter per month)	$359.45	$359.45

Incremental Rates: (applicable to all consumption above base levels)		
Base Levels:		
Demand Levels (ave. monthly base level kW)	Summer	Winter
On-Peak Mid-Peak Off-Peak Super Off-Peak Non-Time Related	11,512 10,856 9,552 NA 11,512	NA 8,812 7,576 7,576 8,812
Consumption Levels (ave. monthly usage kWh)		
On-Peak Mid-Peak Off-Peak Super Off-Peak	1,208,044 1,646,208 2,710,710 NA	NA 1,862,044 1,745,326 2,296,481
Charge	All Year	
Demand Charges (per kW above base level)	Avoided Cost plus $1.00 per Summer On-Peak kW (rate varies with each rate period)	
Energy Charges (per kWh)	Avoided Cost plus $0.02 per kWh (rate varies with each rate period)	
Public Utilities Commission (PUC) and Low Income	As determined	

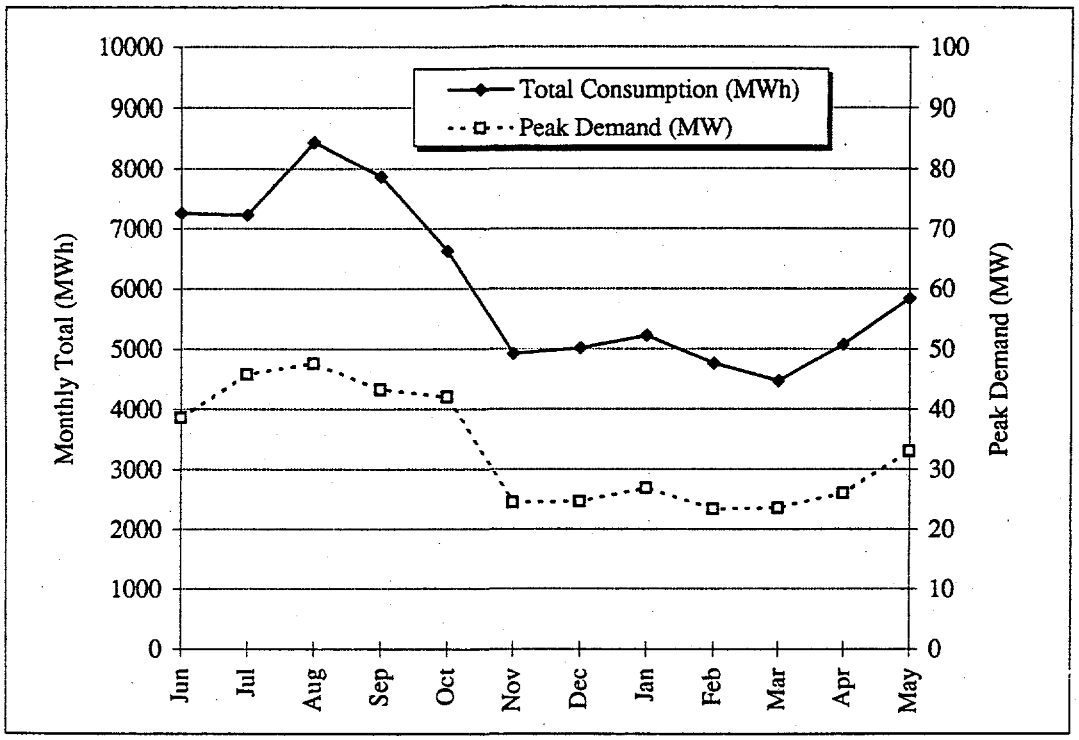

Figure 3.1. Monthly Electrical Energy Consumption and Peak Demand for the Period June 1992 Through May 1993

Table 3.3. Overall Fort Irwin Electric Consumption (MWh/year)

Sector	Consumption (MWh/year)	Percent of Consumption
Buildings	58,106	81.1%
Water Supply/Sewage Treatment	7,876	11.0%
Transformer Losses	2,392	3.3%
Street/Lot Lighting	1,764	2.5%
Fort Irwin School	1,100	1.5%
Trailer Sites	422	0.6%
General's Quarters	21	<0.1%
Total	71,681	100.0%

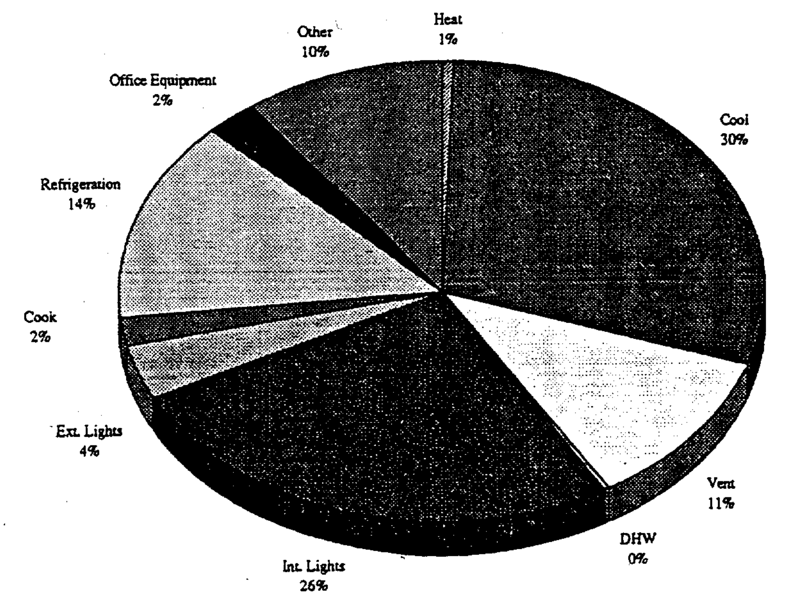

Figure 3.2. Fort Irwin Building Sector Electrical Energy Use (basewide total is 58,100 kWh)

The total consumption is apportioned by building type and by primary end use in each building type.

3.1.2 Electrical Demand Summary

Time-of-use data was collected through PNL metering equipment as part of a separate study sponsored by FORSCOM. The metering was completed for all five main feeders and produced good usable data for two-week periods in April, June, and August of 1990. The study results show that the overall Fort Irwin demand profile is generally flat, indicating little easy opportunity for any peak shaving options that do not involve general load reduction. Figure 3.3 presents the average weekday load profiles for the available metered data in April, June, and August. Figure 3.4 presents the corresponding profiles for weekends.

Additional detail on Fort Irwin feeder demand can be found in the Mobile Energy Laboratory (MEL) report for FEMP titled *Test Report for Fort Irwin: Electric Substation Monitoring*.

3.2 Propane Supply Source Description

Propane is supplied to Fort Irwin through a competitive contract and delivered to a central propane storage area consisting of four 30,000-gallon tanks. The propane is distributed through 8-, 6-, 4-, and 2-inch lines throughout the Fort and is used primarily for heating, cooking, and water heating. At the time of this analysis, the propane rate was 47.3 cents per gallon. Overall propane use at Fort Irwin is shown in Table 3.4, while propane consumption by end use within the building sector is shown in Figure 3.5.

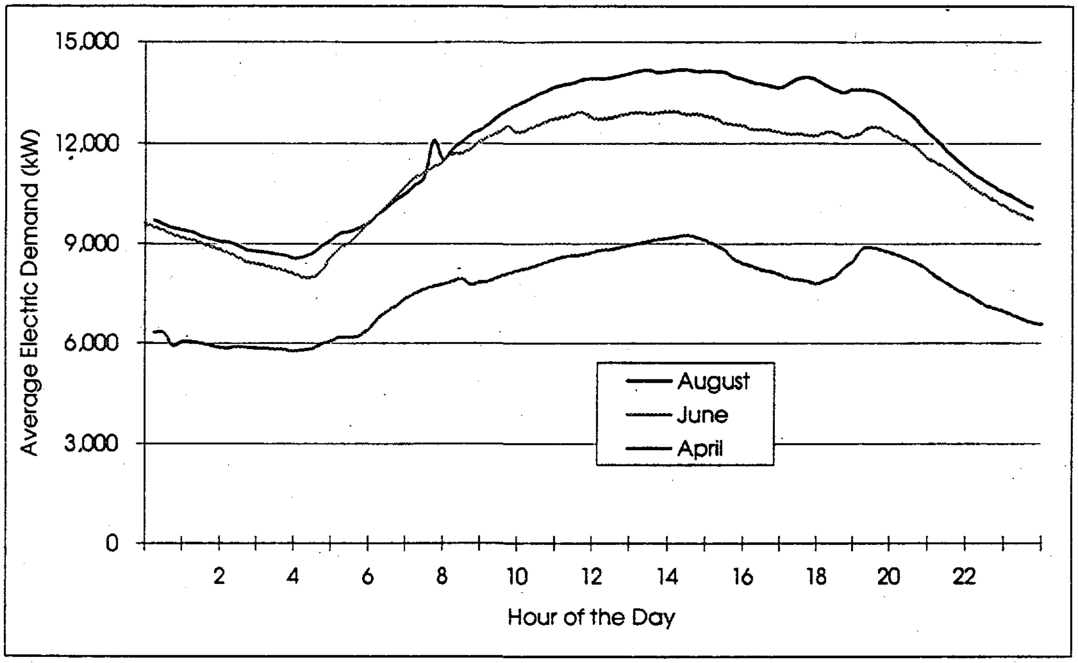

Figure 3.3. Weekday Average Electrical Load Profile

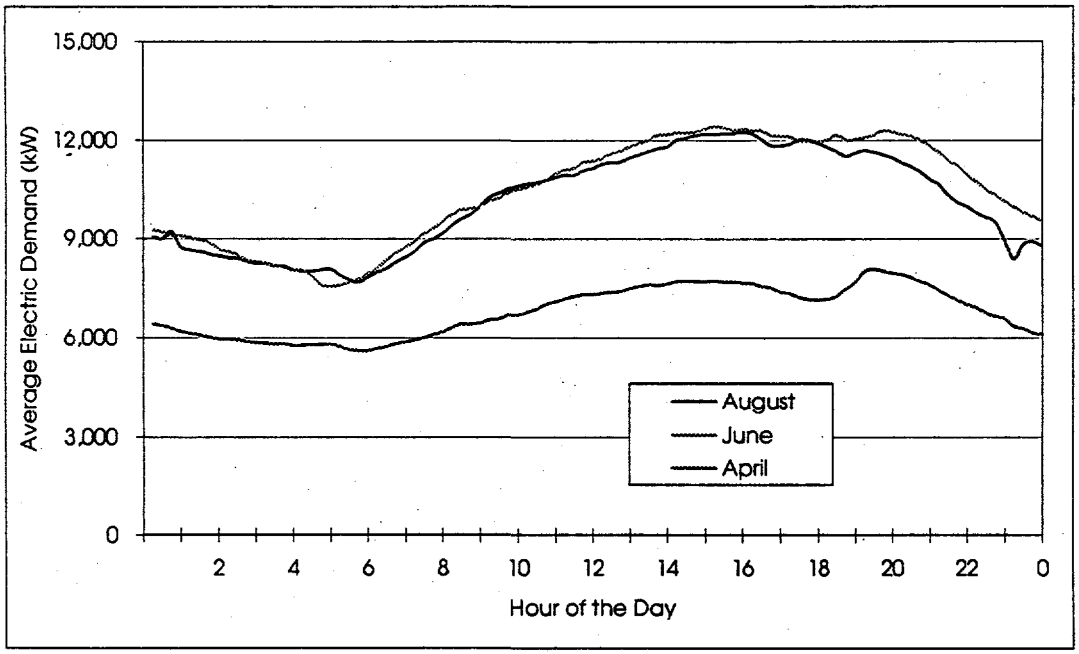

Figure 3.4. Weekend Average Electric Load Profile

Table 3.4. Overall Fort Irwin Propane Consumption (MBtu/year)

Sector	Consumption (MBtu/year)	Percent of Consumption
Buildings	213,874	94.7
Fort Irwin School	11,582	5.1
Trailer Sites	217	<0.1
General's Quarters	107	<0.1
Total	225,780	100.0

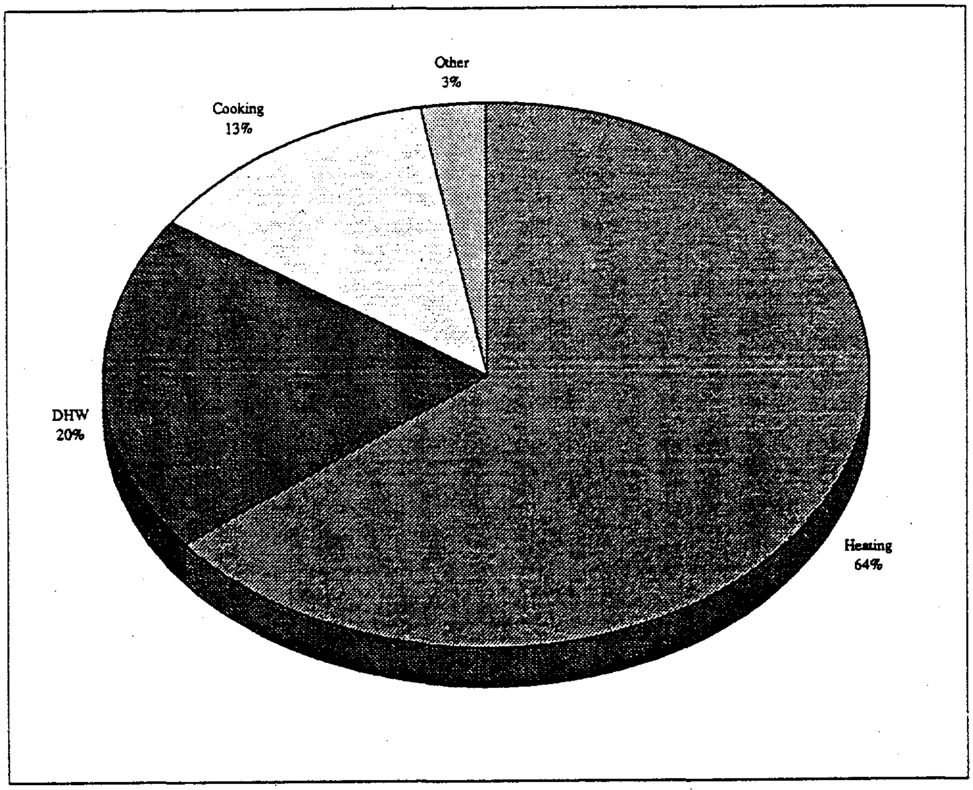

Figure 3.5. Fort Irwin Annual Propane Consumption (basewide building total is 213,800 MBtu)

3.3 Vehicle Fuel Supply Source Description

Fuels for vehicle use are supplied to Fort Irwin by various contract suppliers and stored at point-of-use locations in commercial areas. The primary fuels are gasoline, diesel, JP-4 (aviation fuel), and JP-8 (combination aviation/ground fuel). Portions of each of the fuels are used for field training operations by the rotational units that cycle through Fort Irwin. Table 3.5 lists vehicle types, fuel, and number of vehicles. Table 3.6 provides details on annual consumption as well as estimates of use during training operations.

Table 3.5. Onsite Vehicle Inventory (as of 1993)

Vehicle Type	Fuel Type	Number of Vehicles
Sedan	Gasoline	72
Ambulance	Gasoline	3
Truck	Gasoline	116
Truck	Diesel	12
Truck w/Trailer	Diesel	5
Pickup Truck	Gasoline	82
Passenger Van	Gasoline	91
Passenger Van	Diesel	3
Bus	Diesel	12
Forklift	Diesel	16
Misc. (Backhoe, Grader, etc.)	Diesel	11

Table 3.6. Sample Vehicle Consumption by Fuel Type

Fuel Type	Annual Consumption (Gallons)	Percent Used for Rotational Training[(a)]
Gasoline	446,098	30
Diesel	3,718,042	74
JP-4	770,500	63
JP-8	1,367,750	69

(a) The balance of consumption is used for standard operations not associated with rotation unit activity.

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. PNL uses two methods to select, evaluate, and prioritize these energy resource opportunities (EROs). The first method is the Facility Energy Decision Screening (FEDS) Model. FEDS is a multi-level software tool designed to provide a comprehensive approach to fuel-neutral technology-independent integrated (energy) resource planning and acquisition. FEDS Level-1 is a menu-driven, DOS-based software program designed for installation energy managers as a screening tool.

FEDS Level-2 is a Windows-based software program that can be used by facility energy managers to identify, characterize, and assess individual energy projects. However, Level-2 goes to the next level of detail, providing explicit information on energy and cost savings, as well as the estimated investment requirement for specific technology retrofits. Level-2 is the appropriate analysis to follow positive Level-1 results. Level-2 allows the user to enter installation-specific data inputs to replace the inferred default values from Level-1, tailoring the analysis to the installation and providing more accurate and detailed economic findings.

At this point in the software development, Level-1 and Level-2 analyze most major building end uses (heating, cooling, lighting, envelope insulation, and service hot water), including their interactive effects (e.g., the effect a lighting technology has on heating and cooling loads), and provide specific cost, energy (and demand changes), and life-cycle cost information for cost-effective technologies.

The second method PNL uses addresses those EROs not specifically analyzed by the FEDS software. This analytical approach is a three-step manual calculation process that has been developed by PNL to make ERO selection, evaluation, and prioritization a manageable process. The steps in the manual process are the following:

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, and other local conditions that affect ERO viability, and solicit 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. An analysis is performed comparing the operating and economic performance of the 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 a life-cycle cost (LCC) analysis and rank EROs by net present value (NPV), so that 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 used in both the Level-2 and manual methods is required by and complies with 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 Appendix B.

4.1 Resource Assessment Results

This section summarizes the results of the ERO analysis and aggregates the savings potential into major end-use categories. The specific EROs are described in detail in Volume 3 of this series of reports. Analysis results are presented in 19 common energy-use categories (e.g., boilers and furnaces, service hot water, 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 Fort Irwin is approximately $24 million in 1994 dollars (1994$). The PV of the energy and demand, operations and maintenance (O&M), and replacement savings associated with this investment is approximately $87 million, for an overall NPV of $64 million.

Table 4.2 provides a breakdown and summary of the economics of the cost-effective energy resource opportunities at Fort Irwin. The electric utility supplier, Southern California Edison Company (SCE), has stated that Fort Irwin can

Table 4.1. Total Savings, Cost, and Net Present Value (1994$)

Total Present Value of Installed Cost	Total Present Value of All Cost Savings	Total Net Present Value
$23,908,628	$87,274,447	$63,625,347

Table 4.2. Summary of the Cost-Effective Energy Resource Opportunities at Fort Irwin (1994$)

ERO Category	Present Value of Installed Cost	Present Value of Energy and Demand Savings	Present Value of O&M Savings	Present Value of Replacement Savings	Present Value of Total Savings	Total Net Present Value
Lights (Level-2)[a]	4,393,028	17,464,385	0	4,184,358	21,648,743	17,255,714
Vehicles	2,047,000	5,662,859	6,475,790	0	12,138,649	10,091,649
Envelope	1,400,907	11,619,936	0	-789,727	10,830,209	9,429,302
Roof (Level-2)[a]	2,005,349	8,131,276	0	0	8,131,276	6,125,922
Fam. Hsg. HVAC	7,086,917	12,291,871	281,903	-241,994	12,331,780	5,244,863
Lighting Controls	180,827	2,512,676	719,268	0	3,231,943	3,051,116
Motors	1,362,331	4,051,014	-4,133	-504,490	3,542,390	2,180,059
HVAC	279,627	2,565,025	0	-126,243	2,438,782	2,159,155
Trans. & Dist.	2,543,519	2,242,172	-109	2,147,346	4,389,410	1,845,890
Hot Water (Level-2)[a]	188,447	1,743,372	0	0	1,743,372	1,554,924
Wall (Level-2)[a]	907,261	1,840,887	0	0	1,840,887	933,622
Central Chillers	354,000	1,273,017	-25,831	0	1,247,186	893,186
DHW & A/C	118,124	1,001,673	-32,719	-53,507	915,446	797,322
Wells	210,500	718,156	-4,305	51,131	764,981	554,481
A/C	90	539,429	-1,550	0	537,879	537,789
Heating	235,202	700,930	0	22,215	723,146	487,944
Controls	150,400	532,652	0	-68,127	464,525	314,125
Cooling (Level-2)[a]	165,900	274,395	0	0	274,395	108,496
Heating (Level-2)[a]	13,016	45,366	0	0	45,366	32,352
Totals:[b]	23,908,628	72,211,089	7,408,314	4,620,963	872,474,447	63,625,347

(a) Data of this level of detail are not normally available form FEDS Level-2. All values from the Level-2 software are approximate and are shown only to represent the magnitude of the savings from each end use.
(b) These totals are the sum of the manual EROs and the output from the Level-2 software. They will not necessarily be the sum of the numbers above.

participate in its rebate program. Therefore, this analysis was completed using all applicable SCE rebates. Rebate amounts are included in the economic assumptions and results of each ERO section. If no cost-sharing with the utility can be arranged, the economic analysis can be redone any time.

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

Accompanying Table 4.2 is Table 4.3, which presents a breakdown and summary of both the energy and demand savings for the first-year and full implementation of the cost-effective energy resource at Fort Irwin. The "NAs" in the table reflect that the FEDS model does not report first-year savings--it works strictly on an LCC basis. Any differences between first-year and full implementation results are due to replace-on-failure EROs, which FEDS does not consider.

Table 4.3. Summary of the Energy and Demand Savings

ERO Category	First-Year Energy Savings (MBtu)	First-Year Demand Savings (kW-mo)	Full-Implement Energy Savings (MBtu)	Full-Implement Demand Savings (kW-mo)	Annualized Energy and Demand Savings (1994$)
Lights (Level-2)[a]	NA	NA	34,815	2,487	1,014,144
Fam. Hsg. HVAC	76,678	15,226	76,678	15,226	713,785
Envelope	21,862	17,099	21,862	17,099	674,766
Roof (Level-2)[a]	NA	NA	45,939	621	472,181
Vehicles	14,638	-180	14,638	-180	328,840
Hot Water (Level-2)[a]	NA	NA	40,609	20	242,457
Motors	7,814	7,343	7,814	7,343	235,241
HVAC	15,058	1,690	15,058	1,690	148,950
Lighting Controls	5,992	0	5,992	0	145,910
Trans. & Dist.	2,203	3,708	6,076	7,223	130,202
Wall (Level-2)[a]	NA	NA	10,653	123	106,898
Central Chillers	1,099	2,110	1,099	2,110	73,924
DHW & A/C	4,345	2,198	4,345	2,198	58,167
Wells	0	1,097	0	1,097	41,703
Heating	4,682	727	4,713	742	40,703
Cooling (Level-2)[a]	NA	NA	962	143	35,400
A/C	935	1,129	935	1,129	31,324
Controls	1,508	2,186	1,508	2,186	30,931
Heating (Level-2)[a]	NA	NA	-71	0	3,976
Totals:	156,813	54,331	293,623	61,256	4,529,501

(a) The NAs in the table for Level-2 results reflect that FEDS does not consider replace-on-failure options.

For EROs analyzed by the FEDS Level 2 software, lighting EROs represent the greatest efficiency resource opportunity, accounting for over $17 million of the total $64 million NPV and $4 million of the total $25 million installed cost. The remaining ERO categories have NPVs ranging from $6 million to $1 million, except for cooling and heating EROs, which are only marginally cost-effective with NPVs of $108,000 and $32,000, respectively.

For non-building EROs, vehicles represent the greatest efficiency resource opportunity, accounting for $10 million of the total $64 million NPV and over $2 million of the total $25 million installed cost. The remaining non-building ERO categories have NPVs ranging from $9 million to $314,125.

Tables 4.4 and 4.5 present the breakdown and summary of the total fuel balance at Fort Irwin. Table 4.4 shows the energy consumption and savings predicted by the Level-2 software for those EROs currently analyzed by Level-2. Table 4.5 shows the energy consumption and savings predicted for the EROs not covered by Level-2. The existing energy consumption in Table 4.4 is calculated by Level-2 based on a 30-year average weather file, while the energy data in Table 4.5 is for FY90, as reported in the Volume 2 Baseline Detail companion report to this document. Total fuel use after ERO implementation was determined, where possible, by subtracting the total fuel savings from the total existing fuel use. The "NAs" in the table reflect that there are no demand charges for fossil fuels. Note that electric

Table 4.4. Fuel Balance at Fort Irwin: Level-2 EROs

	Existing		Resulting		Net Conservation	
Fuel Type	Energy Use (MBtu)	Demand (kW)	Energy Use (Mbtu)	Demand (kW)	Energy Use (MBtu)	Demand (kW)
Chilled Water	24,085	NA	20,118	NA	3,969	NA
District Hot Water	9,238	NA	1,558	NA	7,680	NA
Electricity	304,170	30,097	254,607	26,523	49,562	3,574
Propane	209,098	NA	138,080	NA	71,018	NA
Totals	546,591	30,097	414,363	26,523	132,229	3,574

Table 4.5. Fuel Balance at Fort Irwin: Manual EROs

	Existing		Conservation		New Load		Resulting		Net Conservation	
Fuel Type	Energy Use (MBtu)	Demand (kW-mo)	Energy Use Reduction (MBtu)	Demand Reduction (kW-mo)	Increased Energy Use (MBtu)	Increased Demand (kW-mo)	Energy Use (MBtu)	Demand (kW-mo)	Energy Use Reduction (MBtu)	Demand Reduction (kW-mo)
Diesel	516,808		3,116		0		513,692		3,116	
Electricity	272,217	399,251	43,427	58,042	1,962	180	230,753	341,389	41,465	57,862
Gasoline	81,245		81,245		0		0		81,245	
Natural Gas	0		0		68,784		68,784		-68,784	
Propane	225,780		102,990		0		122,790		102,990	
Totals	1,096,050	399,251	230,778	58,042	70,746	180	936,018	341,389	160,032	57,862

demand is reported as peak kWs by Level-2 but as kW-months for the manual EROs. Since peak demand is charged monthly, kW-months were used to properly track demand charges. The FEDS software does this calculation internally, reporting the difference in the demand for the peak month and the cost savings for the entire year.

For building EROs (analyzed by Level-2), the estimated annual electricity consumption at Fort Irwin is 89,143 MWh (304,170 MBtu). Estimated electrical demand is 30,097 kW. Full implementation of all electric EROs results in a reduction of 14,525 MWh (49,562 MBtu) and 3,574 kW. This represents a reduction of approximately 16.3% over total electricity consumption, and 11.9% over site-wide demand. The estimated annual propane consumption at Fort Irwin is 209,098 MBtu. Full implementation of all propane EROs results in net conservation of 71,018 MBtu, or 34.0% of total consumption. The end uses of chilled water and district hot water were not broken out by fuel. The estimated annual chilled water use is 2,007,034 ton-hours. Full implementation of all chilled water EROs results in a reduction of 330,720 ton-hours, or 16.5% of total consumption. The estimated annual district hot water use is 9,238 MBtu. Full implementation of all district hot water EROs results in a reduction of 7,680 MBtu, or 83.1% of total consumption.

For non-building EROs, the estimated annual electricity consumption at Fort Irwin is 79,779 MWh. Estimated electric demand is 399,251 kW-mo (sum of the daily peak demands for each month). Full implementation of all electric EROs results in a reduction of 12,152 MWh and 58,042 kW-mo. This represents a reduction of approximately 15.2% over total electricity consumption and 14.5% over site-wide demand. The estimated annual fossil fuel consumption (natural gas, #2 fuel oil, propane, gasoline, and diesel) at Fort Irwin is 823,833 MBtu. This total excludes any diesel and gasoline used for vehicles not addressed through EROs. Full implementation of all fossil fuel EROs results in conservation of 187,351 MBtu and a new load of 68,784 MBtu, for a net reduction of 118,567 MBtu. This represents conservation of 22.7% of total consumption, new load of 8.3%, and an overall decrease of 14.4%.

The energy savings potential from full implementation of all building energy EROs is illustrated in Figure 4.1; non-building EROs are shown in Figure 4.2.

4.2 Identification of Building Set Energy Projects

The results of the FEDS analysis at a federal facility can be used in a variety of ways to identify specific energy-efficiency improvement projects. For example, an energy project could be a base-wide application of an individual technology retrofit measure, such as the replacement of all motors with high efficiency, variable speed motors. Or an energy project could also be an aggregation of several energy efficiency technology improvements bundled together but applied to a particular building or set of buildings with the same general characteristics, such as age and/or function. The advantage of bundling individual EROs is that it is possible to include some measures that, by themselves, would not be economical and therefore not be implemented. But, bundled together with other more economical EROs applied to the same building set at the same time, the economics can remain attractive overall, and a greater level of efficiency improvement is achieved. In the selection process used at Fort Irwin, we assumed that there were no critical base mission issues or external factors to alter the initial ranking of energy projects.

Within each individual building energy project, the typical EROs usually involved lighting retrofits, envelope upgrade measures, hot water conservation measures, and HVAC system improvements. The order in which these measures are installed in a building is critical because of the interactive effects between measures such as lighting and the HVAC system load requirements. The preferred order of completion is 1) measures that apply to the building envelope, and 2) service hot water. The lighting retrofits are completed only

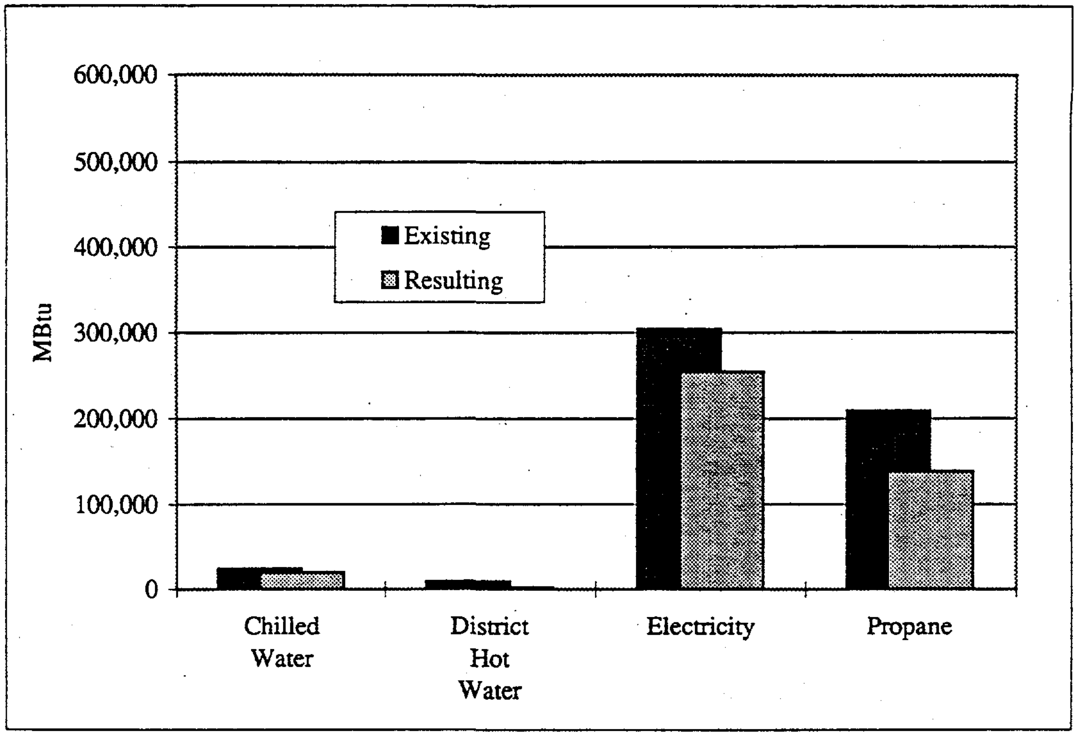

Figure 4.1. Energy Resource Potential for Building EROs

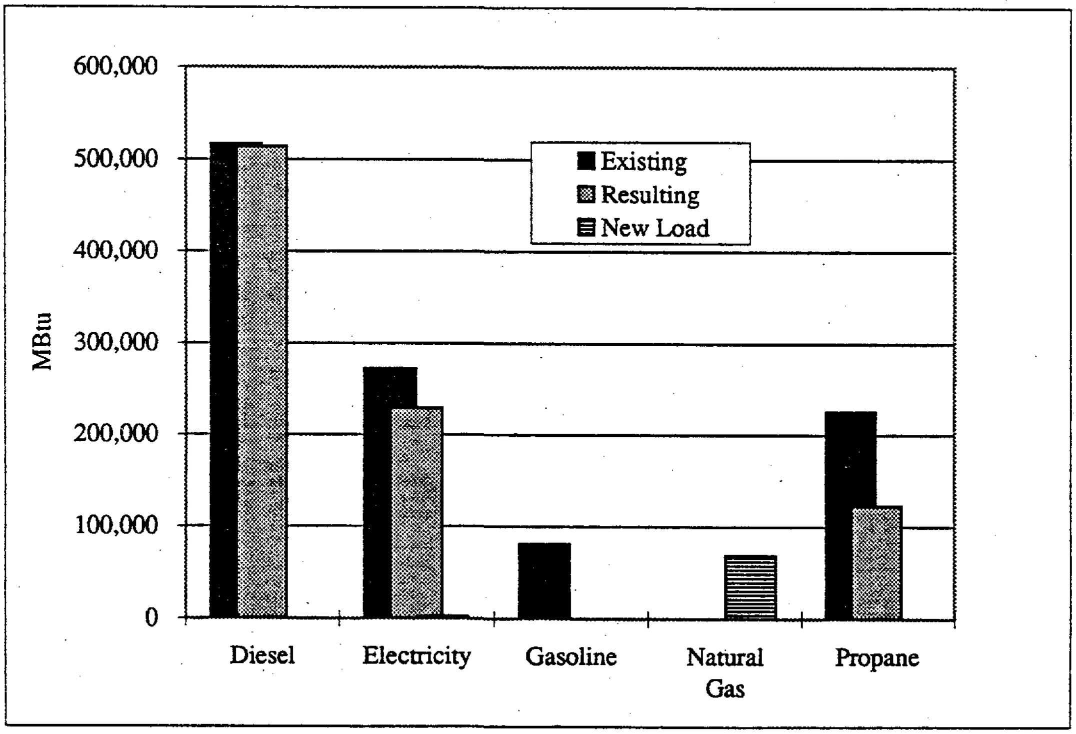

Figure 4.2. Energy Resource Potential for Non-Building EROs

after considering the interactive effect of more efficient lighting (reduced internal heat gains) on the heating loads on the HVAC system to ensure that the system can handle the new heating loads. The HVAC system should be improved last, after a new building baseline operation is established and the new heating/cooling loads are known for the building's new-energy efficient configuration.

If conditions at the federal facility remain relatively unchanged over time, the existing FEDS output files can be used to identify new energy projects. However, if conditions change or significant energy improvements are made, it is recommended that the FEDS assessment be repeated with updated baseline information to derive new energy projects.

The procedures for identifying the energy projects described above were applied to the database of information generated from the FEDS analysis. Table 4.6 lists the top energy conservation projects at Fort Irwin, ranked by net savings of the combined EROs for that building set. Also included in the table are the total annual energy and demand savings, the present value of the installed cost savings, and the savings-to-investment ratio (SIR). A more detailed description of the specific recommended energy-efficiency measures for each building set can be found in Appendix C.

Table 4.6. Summary of the Top 10 Building Energy Projects at Fort Irwin

Building Set	SIR	Annual Energy Saving (MBtu)	Annual Demand Savings (kW)	Value of Energy Savings	Value of Demand Savings	Present Value of Installed Cost Savings	Present Value of Energy and Demand Savings	Net Savings
FH DUPLEX 01	3.5	11353	2462	$136,150	$69,627	$1,107,932	$3,702,924	$2,619,960
FH DETACHED 01	5.0	4639	1899	$63,832	$30,029	$598,269	$2,868,276	$2,246,378
ADMINISTRATION 09	3.3	3709	254	$72,594	$27,017	$752,207	$2,468,683	$1,933,705
FH 3 OR MORE 02	2.6	14425	2524	$178,774	$159,247	$876,083	$2,199,434	$1,631,549
ADMINISTRATION 03	3.4	2425	137	$45,248	$14,462	$342,290	$1,175,987	$1,106,009
SHOPS 04	13.3	388	30	$7,602	$3,085	$85,401	$1,134,504	$1,062,354
FH DUPLEX 03	2.6	11303	46	$69,987	$4,687	$488,746	$1,290,527	$1,010,499
RECREATION 02	14.6	96	5	$1,552	$441	$68,076	$991,341	$934,389
FH 3 OR MORE 03	2.9	4835	54	$40,886	$5,750	$306,248	$894,407	$822,314
SCHOOL/TRAINING	7.7	924	81	$19,365	$8,614	$91,388	$701,634	$742,742

5.0 Implementation Strategy

Current implementation activities have focused on taking advantage of limited programs offered through SCE and/or MILCON/ECIP and FEMP funding sources. While this is a step in the right direction, failure to develop an overall plan will result in a piece-meal approach in the IRP process and could result in missed opportunities to combine or coordinate several programs to maximize both energy and overall cost savings.

The fundamental purpose of the integrated resource planning process is to develop an analytical and rational approach to reducing energy consumption (and energy cost) at Fort Irwin NTC. In the process, energy resource opportunities (EROs) are identified and a framework for a long-term energy management established. This plan will identify a strategy for a long-term working relationship with SCE to take full advantage of the utility incentives offered through promotional, DSM, and ENVEST programs.

A series of implementation planning meetings was held in Huntsville, Alabama, in 1993 and 1994. Participating in these meetings were staff from Fort Irwin, FORSCOM, Huntsville U.S. Army Corps of Engineers (COE) and the Pacific Northwest Laboratory. The objectives of these meetings were threefold: identify major energy project groups, time-phase the projects, and integrate the project into the implementation plan. After the final meeting in mid-1994, the draft Fort Irwin NTC *Extended Energy Project Implementation Plan* (EEPIP) was issued by the COE Division (U.S. Army Corps of Engineers 1994). This plan is designed to maximize acquisition of energy- efficiency technologies while maintaining the necessary flexibility to respond appropriately to future requirements related to mission and changes in force structure. This plan is designed to identify all electric and fossil fuel cost-effective energy projects; develop a schedule for project implementation considering project type, timing or related construction, capital requirements, and energy and energy dollar savings potential; and obtain the least expensive financing required to implement total energy efficiency.

The five-year plan is extremely dynamic, responding to the annual cycle of available federal funds or changes in utility DSM programs. Table 5.1 lists the highest priority energy projects and potential funding sources by year. Greater detail on each project can be found in the EEPIP.

Table 5.1. Top-Rated Energy Improvement Projects for the Period 1994-1999

Year	Energy Project	Funding Source
1994	Reverse Osmosis System	ECIP, Army O&M
	Electric Motors (replace immediately)	ECIP, DSM, FEMP
	Light Controls	DSM, Army O&M
	Basewide Solar Evaluation	FORSCOM, NREL
	Energy Standards for New Construction	Army O&M
1995	Domestic Water Heating - Residential	FEMP, Army O&M
	Electric Motors - Replace on Failure)	Army O&M, DSM
	Power Factor Correction	Army O&M
	Boiler Equipment Modifications	ECIP, FEMP, DSM
	Electric Motors - Variable Speed Drives	DSM
1996	Interior/Exterior Occupancy Sensors - Non-Residential	TBD[a]
	Enclosed Vestibules - Non-Residential	TBD
	Infrared Space Heaters - Non-Residential	TBD
	Appliance Upgrades - Residential	TBD
	Interior Lighting - Residential	TBD
1997	Waste Water Treatment with Methane Recovery	TBD
	Chiller Modifications - CFC Phaseout	TBD
1998	Conversion of Gasoline-Powered Vehicles	TBD
	Building Envelope Upgrades - Residential	TBD
1999	Sewer and Water Privatization	TBD
	Water Heating - Non-Residential	TBD

(a) TBD = to be determined.

6.0 Conclusions and Recommendations

The integrated resource assessment at Fort Irwin National Training Center (NTC) was a major effort to identify various ways to meet the goals established under Executive Order 12902. The significant conclusions and lessons learned from this work are summarized in the following paragraphs.

The systematic approach was used to identify energy resource opportunities (EROs) that provide an overall framework for long-range energy planning to meet the mandated energy-reduction goals. The projects identified from this analysis can be implemented over a period of several years as funding is available. Specific requests for funding from federal sources may require that the analysis performed in this study be updated to include the latest information regarding building characteristics, mission requirements, and current energy uses.

Substantial reductions in energy use and cost savings are available at Fort Irwin NTC even with the exceptionally low cost of energy for electricity and propane. Building EROs analyzed in this study provide a savings of 24% of the annual energy consumption, while the non-building EROs analyzed add an additional 15% annual energy consumption savings.

In most cases, the analysis did not include the value of any rebates that could be obtained from Southern California Edison Company (SCE). However, SCE has offered to establish an overall DSM program for Fort Irwin NTC through SCE's ENVEST program. Mutually agreeable projects would be financed through the utility, with the cost being applied to the monthly billing. In this fashion, Fort Irwin NTC would not be required to seek up-front funds to implement various energy projects. However, the ENVEST program is not the only source of funds available to Fort Irwin NTC for implementation of energy projects. Other sources include MILCON/ ECIP and FEMP.

Other potential sources of funds are SCE's DSM programs and the ENVEST-sponsored comprehensive energy-efficiency programs.

The overall energy plan and associated implementation process, although predominately directed toward acquiring energy-efficient technologies, also must consider and integrate other issues that have the potential to affect energy consumption. Examples of other issues include regular reviews of utility rate schedules, energy standards for retrofit and new construction, and institutional procedures that ensure energy-efficient technologies are installed when replace-on-failure occurs.

The Energy Policy Act of 1992 provides Fort Irwin NTC 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 life-cycle cost methodology (10 CFR 436) as all other EROs evaluated in this assessment.

7.0 References

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Appendix A

Building Set Characteristics

Appendix A

Building Set Characteristics

Building Set ID	No.	Average Year Built	Area (ft^2)
ADMIN-01	4	1949	10,961
ADMIN-02	6	1987	25,651
ADMIN-03	42	1945	85,723
ADMIN-03a	1	1946	2,000
ADMIN-04	1	1944	13,612
ADMIN-05	16	1953	59,798
ADMIN-06	2	1967	18,263
ADMIN-06a	2	1966	5,152
ADMIN-07	3	1985	61,704
ADMIN-07a	2	1986	15,002
ADMIN-08	4	1984	84,128
ADMIN-09	55	1988	257,040
BARRACKS-01	1	1953	6,265
BARRACKS-02	32	1953	198,952
BARRACKS-03	2	1965	52,208
BARRACKS-04	3	1967	127,677
BARRACKS-05	1	1989	4,032
BARRACKS-06	6	1985	43,560
BARRACKS-07	9	1987	243,239
CHAPEL-01	2	1948	3,444
CHAPEL-02	1	1968	15,930
CLINIC-01	1	1987	12,820
CLINIC-02	4	1944	8,304
CLUBS-01	1	1960	6,300
CLUBS-02	2	1943	16,109
CLUBS-03	1	1989	25,062
COMMISSARIES-01	1	1988	56,500

Building Set ID	No.	Average Year Built	Area (ft^2)
DINING HALLS-01	4	1962	6,556
DINING HALLS-02	10	1987	13,520
DINING HALLS-03	7	1946	19,052
DINING HALLS-04	1	1967	13,379
DINING HALLS-05	1	1988	3,520
DINING HALLS-06	1	1984	10,860
ELECTRONICS-01	5	1961	796
ELECTRONICS-02	3	1984	3,728
ELECTRONICS-03	1	1970	4,771
EXCHANGE FACS-01	2	1987	5,660
EXCHANGE FACS-02	3	1957	12,067
EXCHANGE FACS-03	1	1963	18,567
EXCHANGE FACS-04	1	1988	42,957
FH-3 or more-01	36	1966	179,781
FH-3 or more-02	125	1984	839,604
FH-3 or more-03	59	1990	496,370
FH-Detached-01	286	1961	195,800
FH-Detached-02	47	1985	113,542
FH-Detached-03	81	1990	208,025
FH-Duplex-01	108	1963	323,431
FH-Duplex-02	13	1983	51,350
FH-Duplex-03	117	1990	558,965
GUEST HOUSES-01	6	1987	11,046
GUEST HOUSES-02	10	1982	12,000
HANGAR-01	1	1944	8,100
HOSPITAL-01	1	1968	63,818
LABS-01	1	1953	6,265
LABS-02	1	1946	3,150

Building Set ID	No.	Average Year Built	Area (ft^2)
MILITARY OTHER-01	38	1965	12,462
MILITARY OTHER-02	36	1986	15,899
MILITARY OTHER-03	1	1987	5,760
MILITARY OTHER-04	2	1978	1,778
MILITARY OTHER-05	4	1987	11,944
MWR-01	8	1967	1,638
MWR-02	8	1986	21,236
MWR-03	1	1987	12,660
MWR-04	5	1949	15,947
MWR-05	1	1965	9,271
MWR-05a	1	1968	2,487
MWR-06	3	1983	15,610
MWR-07	1	1985	23,680
PROD/PROCESS-01	50	1971	17,012
PROD/PROCESS-02	3	1986	10,900
RECREATION-01	3	1962	6,845
RECREATION-02	3	1965	39,748
RECREATION-03	1	1969	10,416
RECREATION-04	1	1986	23,150
SCHOOL/TRAINING-01	2	1964	2,160
SCHOOL/TRAINING-02	15	1985	37,116
SCHOOL/TRAINING-03	5	1958	17,610
SECURITY-01	6	1981	580
SECURITY-02	2	1945	8,766
SECURITY-03	1	1985	7,600
SHOPS-02	17	1984	60,817
SHOPS-03	17	1946	67,658
SHOPS-04	2	1952	55,184
SHOPS-05	10	1967	53,342
SHOPS-06	2	1987	7,680
SHOPS-07	4	1985	134,888

Building Set ID	No.	Average Year Built	Area (ft^2)
STORAGE-01	23	1984	40,520
STORAGE-02	141	1961	185,935
WAREHOUSE-01	39	1949	28,728
WAREHOUSE-02	8	1964	25,561
WAREHOUSE-03	3	1983	4,167
WAREHOUSE-04	2	1986	20,559
WAREHOUSE-05	27	1946	89,826
WAREHOUSE-06	2	1956	8,665
WAREHOUSE-07	2	1954	81,680
WAREHOUSE-08	2	1968	13,249
WAREHOUSE-09	3	1985	14,325
WAREHOUSE-10	3	1987	39,375
WAREHOUSE-11	1	1987	14,500

Appendix B

Life-Cycle Methodology

Appendix B

Life-Cycle Methodology

According to the provisions of 10 CFR 436, federal agencies are required to analyze all potential energy investments using a life-cycle cost (LCC) methodology developed by the National Institute of Standards and Technology (NIST). The NIST LCC methodology calculates all relevant costs of a project and discounts them to result in present dollars, and then subtracts that sum from a similarly constructed LCC of baseline, current conditions or technology. This difference is called the net present value (NPV) of the action being considered. Actions are cost-effective if the NPV is positive and 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 Federal Energy Management Program (FEMP) model approach for federal energy efficiency using the FEDS (Federal Energy Decision Screening) system to develop a fuel neutral assessment of facilities to identify and quantify energy efficiency resources, supply alternatives, and fuel switching opportunities. All EROs identified by the FEDS assessment and described in this Resource Assessment report 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.* 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:

- Prices for all goods and services (e.g., installed cost of a technology) will 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 from 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 (3.1% real for CY 1994).

- All EROs are analyzed for a 25-year period. This 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 up-front 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. In the presence of constraints on the funding available to implement these projects, some method of prioritizing the projects is needed. It is for this reason that a savings to investment ratio (SIR) is calculated to rank 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 (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 its own 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, which is beyond the scope of a FEDS assessment.

Appendix C

Detailed Description of Energy Efficiency Measures for Buildings

Appendix C

Detailed Description of Energy Efficiency Measures for Buildings

Family Housing Duplex 01 - The top-ranked building set energy project at Fort Irwin focuses on 108 family housing duplexes built in the 1960s. The major retrofit measures identified include building envelope weatherization, sun screen installation on all windows facing south, lighting retrofits, and additional insulation in the walls and ceiling. Details of the retrofit measures and the energy and economic impacts are described in detail in the companion Volume 3 report. The preferred order of completing the individual tasks is to first address those measure that apply to the building envelope, followed by service hot water. The lighting retrofits are to be done only after considering the interactive effect of the reduced internal heat gains on the heating loads on the HVAC system. The HVAC system is the final component to be addressed.

Family Housing Detached 01 - The next ranked energy project at Fort Irwin is directed at the 1960s vintage single family detached housing. As with the similar vintage duplexes, the major cost-effective conservation measures include building envelope weatherization, installation of sun screens on all windows facing south, lighting retrofits, and added insulation to the walls. The annual energy and demand savings for these measures are 11,000 MBtu and 2,400 kW, respectively.

Administration 09 - This building set includes a subset of the newer administration buildings added to Fort Irwin between 1984 and 1990. The energy savings potential from implementing energy projects in these buildings amounts to over 3700 MBtu per year and net savings of $1.9 million. The packages of conservation measures include lighting retrofits, hot water conservation measures, and additional ceiling insulation.

Family Housing 3 or More 02 - This particular building set covers the multi-family housing (three units or more) built between 1983 and 1985. Full implementation of the most life-cycle cost-effective energy conservation measures indicated below would result in an estimated savings of 14,400 MBtu annually. Net savings would be $1.6 million. As with the previous family housing project, the conservation measures focus on hot water conservation, lighting retrofits, and additional ceiling insulation.

Administration 03 - The Administration 03 building set includes 42 of the oldest administration buildings still in use at Fort Irwin. Built between 1944 and 1946, the energy conservation potential in these buildings is significant. The majority of energy savings is from lighting retrofits; the rest is from the hot water conservation package and additional ceiling insulation. Net savings are estimated to be $1.1 million, and annual energy savings are 2,400 MBtu per year.

Shops 04 - The two vehicle maintenance shops built in 1952 are a significant target for an energy efficiency improvement project. The net savings resulting from implementation of the measures identified are estimated to be $1.1 million with an aggregate SIR of 13.3. Energy savings are estimated to be 388 MBtu/year and the annual demand savings would be 30 kW.

Family Housing Duplex 03 - The new family housing duplexes built in 1990 are also a significant target for energy efficiency improvements. For these new residential structures, the measures to be installed include the hot water conservation package, replacement of incandescent lamps with compact fluorescent, and additional ceiling insulation. The annual energy and demand savings for these measures would be over 11,000 MBtu and 46 kW, respectively.

Recreation 02 - This particular building set is composed of the gymnasium, built in 1958, the outdoor swimming pool buildings (1969) and the bowling alley (1967). The biggest energy efficiency improvements come from the lighting retrofits and additional ceiling insulation. Significant savings are also available from the hot water conservation package. Net savings from implementation of all efficiency improvements are estimated to be $0.9 million, with annual energy savings of 96 MBtu. The composite SIR is 14.6.

Family Housing 03 or More 03 - This residential family housing building set consists of 59 multi-family units built in 1990. Total building area is 496,000 square feet. The greatest energy improvements result from replacing the existing incandescent lamps with compact fluorescent (1,200 MBtu annual energy savings) and increasing ceiling insulation to R-19. Net savings resulting from full implementation of all measures in the project would be approximately $0.8 million. The SIR is 2.9.

School/Training 02 - This building set includes 15 individual buildings constructed between 1984 and 1990 that are used for training purposes. The total floor area for the building set is 37,000 ft^2. The recommended energy efficiency improvements include the hot water conservation package, lighting retrofits, and additional ceiling insulation. Net savings for implementing these project are estimated to be $0.7 million, with a 7.7 SIR. Energy savings would be 900 MBtu/year.

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