12-5-93 850

PNL-8424 Vol. 1
UC-350

Fort Drum Integrated Resource Assessment

Volume 1: Executive Summary

September 1993

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

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401. FTS 626-8401.

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

FORT DRUM INTEGRATED RESOURCE ASSESSMENT
VOLUME 1: EXECUTIVE SUMMARY

D. R. Dixon (Project Manager)

P. R. Armstrong
K. K. Daellenbach

September 1993

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

Pacific Northwest Laboratory
Richland, Washington 99352

MASTER

28

ABSTRACT

Some of the most difficult problems that a federal site has in reducing its energy consumption in a cost-effective manner revolve around understanding where the energy is being used, and what technologies could be employed to decrease the 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, he or she may not have the background, training, or resources to determine the most cost-effective options for reducing this energy use. This can lead to selection of suboptimal projects that prevent the site from achieving the full life-cycle cost savings.

The U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP), supported by the Pacific Northwest Laboratory (PNL),^(a) has developed a model program that provides 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 federal 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 five- to ten-year energy management plan that identifies where to start and how to proceed in order to reach the mandated energy consumption targets.

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

This report provides the results of the fossil fuel and electric energy resource opportunity (ERO) assessments performed by PNL at one of Niagara Mohawk's primary federal facilities, the U.S. Army's Forces Command (FORSCOM) Fort Drum facility located near Watertown, New York. It is a companion report to Volume 2, the Baseline Detail, and Volume 3, the Resource Assessment.

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 that 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) could be saved. On October 24, 1992, the Energy Policy Act of 1992 (EPAAct 1992) was issued. It directs federal agencies to reduce energy consumption by 20% from 1985 levels by the year 2000. In an effort to assist federal agencies in meeting this Act, 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.

Fort Drum is a 107,000-acre U.S. Army FORSCOM facility supporting the training mission of 10th Mountain Division near Watertown, New York. In FY 1991, 11,115 active military personnel were assigned to the Fort, and Reserve and National Guard training involved 37,732 personnel. To determine an energy consumption baseline the Fort was divided into six major areas: Old Post commercial, New Post commercial, on-post housing, on-post utility, off-post housing, and the off-post commercial, which includes the Semi Automatic Ground Environment (SAGE) facility in Syracuse, New York. Five of these areas had structures totaling 5,167 buildings and a total area of 12,784,878 ft². On-post utilities include electricity, high temperature hot water (HTHW) system supplied from a privately owned cogeneration plant, water, fire protection, sewage, and outdoor lighting.

Total energy consumption at Fort Drum in FY 1990 was 1,600,903 MBtu, at a cost of \$11,891,000. Characteristic energy types included: electricity, natural gas, #2 fuel oil, propane, high temperature hot water (HTHW), and coal. While electricity, natural gas, #2 fuel oil, and HTHW each made up approximately one-quarter of the total energy consumption, electricity was

nearly one-half of the total energy cost. End uses for electricity included: fans/pumps, lighting, cooling, cooking, refrigeration, and other. Lighting made up nearly one-third of the electric energy consumption. Fossil fuel and HTHW end uses included: space heating, hot water, cooking, generators, vehicle wash, and other. Space heating made up nearly one-half of total energy consumption.

Following life-cycle cost (LCC) guidelines required for all federal energy decisions (10 CFR 436 1990), PNL prioritized the various energy resource opportunities (EROs) by 14 end-use categories (e.g., lighting, hot water, heating, etc.). The net present value (NPV) of the installed cost of all cost-effective EROs at Fort Drum is nearly \$16 million (1992\$). The NPV of the savings associated with this investment is approximately \$47 million (1992\$), for an overall NPV of \$31 million. By implementing all the cost-effective EROs identified in this study, Fort Drum will reduce annual energy use by 230,000 MBtu (14.4%). Annual energy expenditures will decrease by over \$2.4 million (20.4%). The two largest savings potentials by fuel type are the nearly 18,000 MWh of electricity (nearly \$2 million saved annually) and the 268,000 MBtu of #2 fuel oil (over \$1 million saved annually). Because of fuel-switching, conversion of the Old Post from #2 fuel oil and propane use to natural gas, Fort Drum natural gas consumption increases by approximately 200,000 MBtu.

Both fossil fuel and electric EROs were reviewed and categorized for implementation based on a selection criteria methodology determined at an implementation planning workshop held in March 1993 with staff from Fort Drum; the U.S. Army Corps of Engineers (COE) in Huntsville, Alabama; FORSCOM; and PNL. Nine major site-wide projects were selected and prioritized that could be initiated in the early years.

ACKNOWLEDGMENTS

The authors would like to extend our gratitude and acknowledge the assistance of key people who have been allied with the decision-making process for implementation of energy resource opportunities at Fort Drum. These people provided us with detailed and timely information that increased the value and usefulness of our analysis. They are: Stephen E. Rowley and Gordon Greene of the Directorate of Engineering and Housing (Fort Drum, New York); Mark Ginsberg and Lou Harris of the Federal Energy Management Program (Washington, D.C.); Adrian H. Gillespie of the U.S. Army Forces Command (Fort McPherson, Georgia); Bobby H. Starling of the U.S. Army Corps of Engineers (Huntsville, Alabama); and Steven Molodetz and Gary Dembkowski of the Niagara Mohawk Power Corporation (Syracuse, New York).

In addition, the authors thank Jeff E. Dagle, Frank V. Di Massa, Doug B. Elliott, Marlene M. Hale, John M. Keller, David R. Payson, Eric E. Richman, Steve A. Shankle, Greg P. Sullivan, and Randy R. Wahlstrom, all of the Pacific Northwest laboratory (Richland, Washington), for the conscientious, team-oriented, and high-quality assistance they brought to the Fort Drum assessment.

CONTENTS

ABSTRACT	iii
SUMMARY	v
ACKNOWLEDGMENTS	vii
ABBREVIATIONS AND ACRONYMS	xi
1.0 INTRODUCTION	1.1
2.0 SITE CHARACTERIZATION	2.1
3.0 ENERGY USE BASELINE	3.1
4.0 ENERGY RESOURCE OPPORTUNITIES	4.1
4.1 RESOURCE ASSESSMENT	4.1
5.0 IMPLEMENTATION STRATEGY	5.1
5.1 UTILITY PARTNERSHIP STATUS	5.3
6.0 CONCLUSIONS AND RECOMMENDATIONS	6.1
7.0 REFERENCES	7.1
APPENDIX - LIFE-CYCLE COST METHODOLOGY	A.1

FIGURES

2.1	Map of Fort Drum	2.2
3.1	Monthly Average Weekday Demand Profiles, Fort Drum, New York	3.5
3.2	Energy Use by Fuel Type	3.5
3.3	Energy Use by Facility Sector	3.6
3.4	Energy Use by End Use for All Fuels	3.6
3.5	Energy Use by End Use for Electricity	3.7
4.1	Energy Resource Dollar Potential by Fuel Type	4.6
4.2	Energy Resource Potential by Fuel Type	4.6
4.3	Electric Resource Potential by Resource Category	4.7
4.4	Fossil Fuel Resource Potential by Resource Category	4.7
5.1	Preliminary Project Schedule for Fort Drum	5.4

TABLES

2.1	Fort Drum Building Characterization	2.3
3.1	Typical Yearly Energy Consumption and Energy Cost at Fort Drum	3.1
3.2	Energy Consumption by End Use	3.3
4.1	Total Savings, Cost, and NPV	4.2
4.2	Overall Resource Potential	4.2
4.3	Summary of the Electric Efficiency Resource at Fort Drum	4.3
4.4	Summary of the Fossil Fuel Resource at Fort Drum	4.4

ABBREVIATIONS AND ACRONYMS

ACH	Army Community Housing
AFH	Army Family Housing
Btu	British thermal unit
CFR	Code of Federal Regulations
CNG	compressed natural gas
COE	United States Army Corps of Engineers
C/I	commercial/industrial
DoD	United States Department of Defense
DOE	United States Department of Energy
DSM	demand-side management
ECIP	Energy Conservation Investment Program
EMCS	energy management and control system
E.O.	Executive Order
EPAct	Energy Policy Act of 1992
ERO	energy resource opportunity
ESCO	energy services company
EUI	energy-use intensity
FEDS	Facility Energy Decision Screening (system)
FEEF	Federal Energy Efficiency Fund
FEMP	Federal Energy Management Program
FORSCOM	U.S. Army Forces Command
ft	feet
FY	fiscal year
HTHW	high temperature hot water

HVAC	heating, ventilation, and air conditioning
IRP	Integrated Resource Plan
kVA	kilovolt-amperes
kW	kilowatt
kWh	kilowatt-hour
LCC	life-cycle cost
MBtu	million British thermal units
MW	megawatt
MWh	megawatt-hour
Niagara Mohawk	Niagara Mohawk Power Company
NPV	net present value
O&M	operations and maintenance
PNL	Pacific Northwest Laboratory
PX	post exchange
SAGE	Semi Automatic Ground Environment
SES	shared energy savings
SIR	savings to investment ratio
VI	value index
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 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 towards 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), federal agencies have set a goal of 20% reduction in federal facility energy use and industrial process efficiency improvement by the year 2000 (from 1985 levels). 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 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 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

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

of demand-side management (DSM) incentives through rate recovery. It authorizes and encourages federal agencies to participate in utility incentive programs to increase energy efficiency and conserve water. It also establishes a Federal Energy Efficiency Fund to provide grants to agencies to assist them in meeting the energy reduction mandates with \$10 million available in FY 1994 and \$50 million available in FY 1995.

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 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 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. 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, he or she may not have the background, training, or resources to determine the most cost-effective options for reducing this energy use. This can lead to selection of suboptimal projects that prevent the site from achieving the full life-cycle cost savings.

The model program the Federal Energy Management Program (FEMP) has developed constitutes a systematic approach to evaluating energy opportunities which 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 federal 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.

In an effort to assist federal agencies in meeting the conditions of the EPA Act, FEMP, supported by PNL, has been tasked by U.S. Forces Command (FORSCOM) 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 Fort Drum, FEMP is designing a model program for federal customers served by the Niagara Mohawk Power Company (Niagara Mohawk). 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 Niagara Mohawk and have Niagara Mohawk procure the necessary contractors to perform detailed audits and install the technologies.

This report provides a summary of the baseline of energy use information found in Volume 2: Baseline Detail (Dixon et al. 1992a) and of the assessment of energy resource opportunities found in Volume 3: Resource Assessment (Dixon et al. 1992b). In addition, it summarizes a strategy for implementation of this conservation and fuel-switching potential.

The Fort Drum 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 a 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 is provided in the Appendix.

2.0 SITE CHARACTERIZATION

Fort Drum is a 107,000-acre U.S. Army FORSCOM facility situated a few miles east of Watertown, New York, at 44.0°N and 76.0°E. The Fort's mission is to provide training and support for the 10th Mountain Division (infantry) of the U.S. Army. Figure 2.1 details the Fort Drum site plan with a map.

Active military personnel assigned to the Fort numbered 11,115 in FY 1991. Almost all of these people live in military housing. Annual Reserve and National Guard training involved 37,732 military personnel in FY 1991. The average number of Reservists onsite at any time was 3,144. These personnel generally occupied older barracks during their two-week stays. Civilians employed at the Fort numbered 1,501 in FY 1991; these personnel do not live in military housing. Military personnel not assigned to the Fort affect energy consumption to some extent by their use of site facilities such as the post exchange (PX) and recreation centers. There are about 50,000 people in upstate New York who are entitled to use these facilities, but the extent of this use has not been determined.

The Fort is divided into six major areas (for energy consumption and billing purposes), including Old Post commercial, New Post commercial, on-post housing, on-post utility (including exterior lighting, pumping, and transmission and distribution losses), off-post housing, and the off-post commercial, which includes the SAGE facility in Syracuse. Table 2.1 gives the number of buildings and total square feet for each of the areas.

The Old Post contains 694 buildings, not including Army Family Housing (AFH). The Old Post buildings are predominantly one- and two-story frame structures constructed in the 1940s. Many have been renovated with metal siding, wall and attic insulation, storm windows, fluorescent lighting, and coal-to-oil heat conversion furnaces. The two Old Post structures that are exceptions are Building P173-175, a 150,000-ft² barracks built in 1970, and Building P36, a 13,500-ft² clinic built in 1987.

A total of 170 buildings are located on the New Post, situated north of the Conrail railroad spur on approximately 6,000 acres of land. The New Post buildings were constructed during the Fort expansion program of 1985 to 1988.

FIGURE 2.1. Map of Fort Drum

TABLE 2.1. Fort Drum Building Characterization

<u>Fort Area</u>	<u>Number of Buildings</u>	<u>Total Floorspace (ft²)</u>	<u>Percent of Total Floorspace</u>
Old Post Commercial	694	3,075,025	24.1
New Post Commercial	200	3,380,890	26.4
On-Post Housing	2,272	3,183,047	24.9
Off-Post Housing	2,000	2,937,384	23.0
Off-Post Commercial (SAGE) ¹		<u>208,532</u>	<u>1.6</u>
Total	5,167	12,784,878	100.0

There are 15 on-post family housing areas. The Ravenwood area is all-electric. Senior officer dwellings in the Leray area are heated by oil and have electric cooking appliances. All other on-post AFH areas have natural gas service for heating and cooking.

There are 14 off-post family housing areas. Housing is typically grouped in areas of 75 to 300 units and located from 1 to 30 miles outside the Fort. All off-post housing is privately owned. The Fort has long-term operating leases with the private owners and operators. The Clayton, Copenhagen, Gouverneur, Lowville, and Philadelphia areas use propane for heating and cooking; all other areas use natural gas.

The new Wheeler-Sack Airfield is currently under construction east of the New and Old Post areas. Because the airfield is in the initial construction stages, the facilities were not considered in this analysis and the associated floorspace was not included in the baseline.

The SAGE facility, located near the Syracuse airport, was described in the baseline (Volume 2) but not in the development of energy conservation and fuel-switching measures (Volume 3).

3.0 ENERGY USE BASELINE

This section documents baseline energy use at Fort Drum. This analysis examines the characteristics of electric, natural gas, #2 fuel oil, propane, purchased high-temperature hot water, and coal use for FY 1990. It 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 summarizes the typical yearly energy consumption and cost for all facilities at Fort Drum. For each energy type, the yearly 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 yearly usage, from the best available data during 1990 and 1991. The yearly energy consumption was 1,600,903 MBtu, at a cost of \$11,891,000.

TABLE 3.1. Typical Yearly Energy Consumption and Energy Cost at Fort Drum

<u>Energy Type</u>	<u>Yearly Total</u>	<u>Yearly Total [MBtu^(a)]</u>	<u>Percent of Total Energy Consumption</u>	<u>Energy Cost [1990\$ x 10³]</u>	<u>Percent of Total Cost</u>
Electricity	105,849 MWh	361,260 ^(b)	22.6	5,523	46.4
Natural Gas	3,857 ktherm	385,720 ^(c)	24.1	2,353	19.8
#2 Fuel Oil	2,407 kgallon	334,146 ^(d)	20.9	1,661	14.1
Propane	652 kgallon	59,524 ^(e)	3.7	358	3.0
HTHW	458,048 MBtu	458,048	28.6	1,967	16.5
Coal	98 Ton	2,205 ^(f)	0.1	9	0.01
Totals:		1,600,903	100.0	11,891	100.01

(a) 1 MBtu = 1,000,000 Btu.

(b) 3,413 Btu/kWh.

(c) 100,000 Btu/therm; 1,050 Btu/ft³ of natural gas.

(d) 0.1388 MBtu/gal of #2 fuel oil.

(e) 0.0913 MBtu/gal of propane.

(f) 22.5 MBtu/ton of coal.

Table 3.2 breaks down the energy consumption by fuel type and end use for the Fort's six major areas. On the electric side, utility readings and various building meters were used to determine the total electric energy consumption by building type within each area (i.e., old post commercial, etc.). Substation feeder readings were collected for over a year by PNL and gave insight into the time of day consumption at the Fort (see Figure 3.1). These feeder data, along with estimates of energy-use intensities (EUIs), were used to reconcile the energy consumption by building type and end-use category (lighting, heating, cooling, etc.).

Energy consumption is described with the following four figures: Figure 3.2 describes the energy use by fuel type, Figure 3.3 describes the energy use by facility sector, Figure 3.4 describes the energy use by end use for all fuels, and Figure 3.5 describes the energy use by end use for electricity only.

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

	Fort Area						
Fuel Type/End Use	Old Post Commercial	New Post Commercial	On-Post Housing	On-Post Utility	Off-Post Housing	Off-Post Commercial	Total
Electric:							
Fans/Pumps	8,237	31,429	761	0	702	3,559	44,688
Lighting	36,310	54,082	11,977	0	10,527	4,982	117,878
Cooling	1,746	5,955	760	0	702	2,847	12,010
Cooking	0	706	2,921	0	667	0	4,294
Refrigeration	7,301	14,843	9,777	0	9,023	0	40,944
Other	14,161	27,175	26,100	35,817	24,608	13,585	141,446
Total	67,755	134,190	52,296	35,817	46,229	24,973	361,260
Percent of Total	18.8	37.1	14.5	9.9	12.8	6.9	100.0
Natural Gas:							
Heating	0	7,216	171,640	0	95,338	0	274,194
Hot Water	0	5,355	48,180	0	33,999	0	87,534
Food Prep.	0	5,115	6,022	0	8,453	0	19,590
Other	0	4,402	0	0	0	0	4,402
Total	0	22,088	225,842	0	137,790	0	385,720
Percent of Total	0.0	5.7	58.6	0.0	35.7	0.0	100.0
#2 Fuel Oil:							
Heating	252,367	0	2,157	0	0	17,517	272,041
Hot Water	55,637	0	0	0	0	3,337	58,974
Generator	0	0	0	0	0	3,131	3,131
Total	308,004	0	2,157	0	0	23,985	334,146
Percent of Total	92.2	0.0	0.6	0.0	0.0	7.2	100.0
Propane:							
Heating	0	0	0	0	35,137	0	35,137
Hot Water	2,291	0	0	0	12,493	0	14,784
Cooking	5,699	0	0	0	3,904	0	9,603
Total	7,990	0	0	0	51,534	0	59,524
Percent of Total	13.4	0.0	0.0	0.0	86.6	0.0	100.0

TABLE 3.2. (contd)

	Fort Area						
<u>Fuel Type/End Use</u>	<u>Old Post Commercial</u>	<u>New Post Commercial</u>	<u>On-Post Housing</u>	<u>On-Post Utility</u>	<u>Off-Post Housing</u>	<u>Off-Post Commercial</u>	<u>Total</u>
<u>HTHW:</u>							
Heating	0	206,608	0	0	0	0	206,608
Hot Water	0	62,983	0	0	0	0	62,983
Vehicle Wash	0	11,183	0	0	0	0	11,183
Loss	0	177,274	0	0	0	0	177,274
Total	0	458,048	0	0	0	0	458,048
Percent of Total	0.0	100.0	0.0	0.0	0.0	0.0	100.0
<u>Coal:</u>							
Heating/DHW	2,205	0	0	0	0	0	2,205
Total	2,205	0	0	0	0	0	2,205
Percent of Total	100.0	0.0	0.0	0.0	0.0	0.0	100.0
Total:	385,954	614,326	280,295	35,817	235,553	48,958	1,600,903
Percent of Total:	24.1	38.4	17.5	2.2	14.7	3.1	100.0

FIGURE 3.1. Monthly Average Weekday Demand Profiles, Fort Drum, New York (07/91 - 01/92)

FIGURE 3.2. Energy Use by Fuel Type (MBtu)

FIGURE 3.3. Energy Use by Facility Sector (MBtu)

FIGURE 3.4. Energy Use by End Use for All Fuels (MBtu)

FIGURE 3.5. Energy Use by End Use for Electricity (MBtu)

4.0 ENERGY RESOURCE OPPORTUNITIES

The number of conceivable energy resource opportunities (EROs), 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 the following:

- Preliminary Screening. Select promising EROs from a master list (see Table 1.1, Volume 3: Resource Assessment), considering the site's mission, building stock, end-use equipment characteristics, utility characteristics, climate, energy costs, other local conditions that affect 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. 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 third step, LCC analysis and prioritization of EROs, is required by federal law (10 CFR 436). All federal agencies are required to evaluate the LCC of potential energy investments. An LCC evaluation computes the total long-run costs of a number of potential actions, and selects the action that minimizes the long-run costs and maximizes the NPV of the energy investment. These requirements are discussed in more detail in the Appendix.

4.1 RESOURCE ASSESSMENT

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. Analysis results are presented in 14 common energy end-use categories (e.g., lighting, HVAC, refrigeration) and the five facility sectors representative of Fort Drum: New Post commercial, Old Post

commercial, on-post family housing, off-post family housing, and on-post utilities. Savings are indicated by fuel type: fuel oil #2, natural gas, propane, high-temperature hot water (HTHW), and electricity.

As illustrated in Table 4.1, the NPV of the installed cost of all cost-effective EROs at Fort Drum is nearly \$16 million (1992\$). The NPV of the savings associated with this investment is approximately \$47 million (1992\$), for an overall NPV of \$31 million. By implementing all the cost-effective EROs identified in this study, Fort Drum will reduce annual energy use by 230,000 MBtu (14.4%), and annual energy expenditures will decrease by over \$2.4 million (20.4%), as shown in Table 4.2.

Table 4.3 provides a complete breakdown and summary of the electric efficiency resource at Fort Drum.

The Lighting ERO category has the greatest energy conservation potential at Fort Drum. Lighting EROs alone represent almost 70% of the potential reduction in electricity use identified in this study and include the

TABLE 4.1. Total Savings, Cost, and NPV (1992\$)

<u>Total Present Value of Installed Cost^(a)</u>	<u>Total Present Value of Energy Savings</u>	<u>Total Present Value of Demand Savings</u>	<u>Total Present Value of O&M Savings</u>	<u>Total Present Value of All Savings</u>	<u>Total Net Present Value^(a)</u>
\$16,478,259	\$34,018,474	\$6,233,134	\$6,621,546	\$46,873,154	\$30,644,4

(a) Totals in this table do not equal sum of Tables 4.3 and 4.4 because Peak-Shave and CO₂ Sensor EROs are accounted for in both tables.

TABLE 4.2. Overall Resource Potential

	<u>Existing</u>	<u>Resulting</u>	<u>% Reduction</u>
Annual Energy Consumption (million MBtu/yr)	1.60	1.37	14.4
Annual Cost of Energy (million \$/yr) Expenditures	11.89	9.46	20.4

TABLE 4.3. Summary of the Electric Efficiency Resource at Fort Drum

Energy Resource Opportunity Category	Present Value of Installed Cost ^(a)	Annual Energy Savings (kWh)	Value of Annual Energy Savings (1992\$)	Annual Demand Savings (kW-mo)	Value of Annual Demand Savings (1992\$)	Total Net Present Value (1992\$)
Air Conditioning	31,850	25,093	1,470	225	1,241	8,393
CO ₂ Sensors ^(b)	56,430	154,028	7,659	0	0	37,639
Lighting	7,940,028	18,078,203	1,011,494	46,501	256,218	16,578,499
Fluorescent	4,227,477	9,512,174	513,182	28,250	155,656	7,014,250
Incandescent	3,123,671	6,922,986	419,014	15,396	84,833	6,551,533
Exits	530,740	1,020,584	50,825	1,398	7,703	2,476,115
HIDs	58,140	622,458	28,473	1,457	8,026	536,600
Motors ^(c)	477,618	3,387,177	172,059	-1,907	-11,635	1,549,979
Peak-Shave ^(b)	194,000	4,000,000	234,360	31,200	171,912	1,362,873
Streetlights	83,784	1,073,557	49,735	2,596	14,304	938,318
Trans. & Dist.	8,522	756,954	38,291	1,332	7,340	883,150
Weatherization	63,850	197,066	9,767	583	3,212	118,860
Total	\$8,856,082	27,672,078	\$1,524,835	80,530	\$442,592	\$21,477,711

(a) Analysis assumes no utility cost-sharing.

(b) The NPVs of Peak-Shave and CO₂ Sensors include fossil costs/savings.

replacement/retrofit of existing lighting equipment with T-8 lamps, electronic ballasts, optical reflectors, high-pressure sodium and compact fluorescent fixtures, and occupancy sensors.

The use of energy-efficient and two-speed motors accounts for 12% of the kWh savings, and transmission and distribution EROs such as power factor correction and conservation voltage reduction account for slightly under 3% of total electrical savings.

Demand charges constitute approximately 10% of Fort Drum's monthly electric bill. These charges can be reduced by using existing emergency service diesel generators to carry part of the on-post electric load whenever demand approaches the monthly peak. The most reliable and effective way to accomplish this is to modify selected generators, so that they can be used as a power source that can feed into Fort Drum's electrical distribution system.

The Old Post, consisting predominantly of World War II-vintage buildings heated with fuel oil, offers opportunities for fuel-switching to natural gas and replacement or conversion of aging and inefficient boilers, furnaces, and water heaters to new high-efficiency units.

Although most of the buildings on the Old Post have been renovated over the years and have storm windows or double-pane glass and some thermal insulation, significant opportunities still exist for weatherization measures such as weatherstripping, floor and additional ceiling insulation, and window quilts.

A summary of the savings potential categorized by fossil fuel resources is presented in Table 4.4.

TABLE 4.4. Summary of Fossil Fuel Resource at Fort Drum

<u>Energy Resource Opportunity Career</u>	<u>Present Value of Installed Cost^(a)</u>	<u>Annual Energy Savings (MBtu)</u>	<u>Value of Annual Energy Savings (1992\$)</u>	<u>Total Net Present Value (1992\$)</u>
Peak-Shave ^(b)	194,000	-43,451	-216,000	1,362,873
CO ₂ Sensors ^(b)	56,430	2,221	9,539	37,639
Controls	66,090	6,790	31,112	458,647
Furn. & Boilers	2,953,444	51,658	362,185	2,752,818
Hot Water	710,524	8,679	70,730	448,266
Trans. & Dist.	70,130	52,750	226,561	3,749,684
Weatherization	3,821,989	60,513	318,136	1,757,340
Total	\$7,622,177 ^(c)	139,161	\$802,263	\$9,166,754 ^(c)

(a) Analysis assumes no utility cost-sharing.

(b) The NPVs of Peak-Shave and CO₂ Sensors include electric savings.

(c) Does not include Peak-Shave and CO₂ Sensors amounts because they are included in Table 4.3 total.

The heating systems in many of the Old Post buildings are currently regulated by a radio-control system that consists of a central computer and an FM transmitter, with a receiver and a day-thermostat and a night-thermostat in each building. Fort Drum has already purchased much of the hardware required to add most of remaining Old Post buildings to the FM control system. A very cost-effective opportunity exists by funding the installation of this equipment.

Large energy and dollar savings can be also be realized through the repair or replacement of pipe insulation on the HTHW distribution system servicing the New Post. In addition, several sections of the HTHW loop that currently do not provide service to buildings could be decommissioned, resulting in reduced pipeline heat loss and additional dollar savings.

On- and off-post housing units, although relatively well insulated, are prone to draftiness. A "weatherization package" consisting of attic hatch insulation, switchplate gaskets, caulking, and filling plumbing holes and other penetrations with insulation was found to be life-cycle cost-effective, as were window quilts, which provide insulation and reduce infiltration. Finally, the all-electric, on-post family housing units have insufficient ceiling insulation; increasing the insulation in these units up to an R-60 level will be life-cycle cost-effective.

Energy resource potential is described with the following four figures: Figure 4.1 describes the energy resource potential in dollars by fuel type, Figure 4.2 describes the energy resource potential in MBtu's by fuel type, Figure 4.3 describes the electric resource potential by ERO category, and Figure 4.4 describes the fossil fuel resource potential by ERO category.

FIGURE 4.1 Energy Resource Dollar Potential by Fuel Type

FIGURE 4.2 Energy Resource Potential (MBtu) by Fuel Type

FIGURE 4.3 Electric Resource Potential (MWh) by Resource Category

FIGURE 4.4 Fossil Fuel Resource Potential (MBtu) by Resource Category

5.0 IMPLEMENTATION STRATEGY

The purpose of the integrated resource planning (IRP) process is to develop an analytical and rational approach to reducing the energy consumption (and energy cost) at Fort Drum. The implementation step of this process reviews energy resource opportunities (EROs) identified in the integrated resource assessment and develops a framework for a five-year energy management plan. When fully developed this plan will address the types of projects, timing, sources of funding, and other considerations for Fort Drum. In addition, a strategy for negotiating with the electric and gas utility (Niagara Mohawk) needs to be part of this plan to fully take advantage of the utility incentives offered through demand-side management (DSM).

An implementation planning workshop was held in Huntsville, Alabama, on March 2-3, 1993, with staff from Fort Drum, Huntsville U.S. Army Corps of Engineers (COE), and PNL. As part of this workshop, background on the Fort Drum assessment was presented and criteria for selecting projects was discussed. Major selection criteria included:

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

The EROs for electric and fossil fuels were reviewed, and categorized based on the selection criteria and Fort Drum priorities. The EROs related to the New and Old Posts had the highest priority, while family housing (especially the off-post housing) had lower interest. Additional projects were suggested by Fort Drum staff that are not part of the PNL assessment. They have, however, been evaluated by Fort Drum staff and include a basewide energy management and control system (EMCS) and modification of the SAGE facility,

among others. To determine the cost-effectiveness of these additional projects and to be consistent with the PNL assessment, they will need to be evaluated using federally-mandated LCC methodology.

Resulting from the workshop were nearly 400 EROs divided into nine projects to be implemented over a three- to five-year period. Major projects to be initiated immediately included:

- A shared energy savings (SES) project to provide natural gas for space heating and water heating on the Old Post; to enhance the FM control system on the Old Post; and to decommission, insulate, and provide package boilers for parts of the HTHW system on the New Post.
- A DSM project to retrofit lighting on the New/Old Post, provide two-speed motors for building ventilation and sewer lift stations, replace and reconfigure streetlights throughout the Fort, and improve the site's power factor by installing capacitors. This project will be 100% financed by Niagara Mohawk.
- A DSM or Energy Conservation Investment Program (ECIP) project to convert portions of the existing vehicle fleet to compressed natural gas (CNG)-powered vehicles. Niagara Mohawk may pay for the refueling station, and ECIP funding could be used to convert the vehicles.
- A site-funded operations and maintenance (O&M) project to reduce the HTHW supply temperature from the central steam plant. This project involves working with the contractor that operates the central steam plant to lower the supply temperatures to reduce the thermal losses from the distribution pipeline.

Other projects to be implemented in the later years could include:

- a base-wide EMCS for the New Post, and peak-shaving using the existing back-up diesel generators,
- electric technology improvements (lights, HVAC, controls, etc.) at the SAGE facility,
- attic ventilation/insulation in the New Post buildings to reduce heat loss, and prevent ice build-up and leakage,
- weatherization of the Old Post buildings, and
- a variety of improvements for the off-post family housing (lighting, water heating, weatherization, etc.).

Figure 5.1 shows the expected start and duration of some of these projects over a five-year period at Fort Drum. Many of these projects will require several years to design, procure, and fully implement. Verification of the energy savings will continue for the life of the equipment.

5.1 UTILITY PARTNERSHIP STATUS

As part of the 1993 Rate Case settlement, Niagara Mohawk proposed a DSM subscription option for commercial/industrial (C/I) customers. This program has been approved by the New York State Public Service Commission for a three-year trial period. The subscription option allows customers to decide if they want to remain in the subsidized base DSM program and remain eligible for rebates and incentives, or choose the non-subsidized option and develop their own conservation and efficiency program. All customers will continue to pay the DSM administrative costs as part of their electric bills. However, customers choosing the subsidized option will also pay the cost of the rebates and incentives offered to all eligible C/I customers. Customers that choose the non-subsidized option are responsible for the full costs associated with their individual projects, but will not receive any rebates or incentives.

Fort Drum has decided to choose the non-subsidized option and will work with Niagara Mohawk to implement a custom conservation and efficiency program. The sole source contract presently being negotiated with Niagara Mohawk will likely include:

- 100% up-front financing at a competitive interest rate,
- competitive procurement of an energy service company (ESCO) by Niagara Mohawk that will conduct detailed audits, provide design and installation services and construction oversight of all projects,
- verification of savings, and
- payback of all financing costs through the site's electric utility bill, with the costs not to exceed the savings generated from the projects.

FIGURE 5.1. Preliminary Project Schedule for Fort Drum

This contract should be in place by late summer 1993 with initial audits to begin immediately. Niagara Mohawk has provided a letter of intent to Fort Drum, and is already in the process of qualifying several ESCOs that would bid on the projects. Several issues still need to be resolved in regard to financing charges, verification needs, liability clauses, and audit requirements. The main audit requirement question is whether or not the PNL integrated resource assessment meets the audit specifications for choosing the non-subsidized option.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The integrated resource assessment at Fort Drum was the first opportunity to apply this methodology from start to finish at a major site. The significant conclusions and lessons learned from this work include:

- This systematic approach to identifying energy opportunities provides a framework for long-range energy planning which includes a means to achieve the mandated energy reduction goals. The projects identified can be implemented as funding is available over a period of several years.
- Significant energy reduction (14.4%) and cost savings (20.4%) are achievable at Fort Drum even with the recent completion of the new post facilities. The new facilities were not designed with the most energy efficient technologies, and it is cost effective to retrofit lights, motors, etc. on the new post. Significant opportunities exist with the HTHW distribution system at minimal cost.
- DSM funding through Niagara Mohawk appears to be most promising source of funding for electric projects. Other sources such as Energy Conservation Investment Programs (ECIP), Shared Energy Savings (SES), and the Federal Energy Efficiency fund (when funded as part of EPart), should be explored for the non-electric, and fuel-switching projects.
- In future assessments, contract negotiations and verification planning should begin with the utility in parallel with the technical evaluation (i.e., resource assessment), to provide the vehicle for implementation as soon as possible. This would facilitate the initiation of a pilot project, if appropriate, prior to completing the assessment.
- In order to accomplish a comprehensive resource assessment of this nature, the site has to provide significant support in a timely fashion. The energy manager has to be committed to the effort and be willing to provide resources throughout the assessment period.

The major recommendations of this assessment include:

- Pursue DSM contract with Niagara Mohawk. This would be an independent contract as part of the non-subsidized option for DSM.
- Evaluate other sources of funding for projects not included in DSM program with Niagara Mohawk. The Huntsville COE is presently evaluating several of the projects for SES and/or ECIP funding.

- Further evaluation of the compressed natural gas (CNG)-fueled vehicles, SAGE improvements, base-wide EMCS, and attic ventilation projects is required, to assess their relative attractiveness as compared with the other projects. This evaluation should follow the same life-cycle cost methodology (10 CFR, part 436) as all other EROs evaluated in this assessment.

7.0 REFERENCES

10 CFR 436. 1990. U.S. Department of Energy. "Federal Energy Management and Planning Programs." (Revision as of January 1, 1990). U.S. Code of Federal Regulations.

The Energy Policy Act of 1992 (EPAct). Public Law PL 102-486, Washington, D.C., October 24, 1992.

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.

Dixon, D. R., P. R. Armstrong, J. R. Brodrick, K. K. Daellenbach, F. V. Di Massa, J. M. Keller, E. E. Richman, G. P. Sullivan, and R. R. Wahlstrom. 1992a. Fort Drum Integrated Resource Assessment, Volume 2: Baseline Detail. PNL-8424 Vol. 2, Pacific Northwest Laboratory, Richland, Washington.

Dixon, D. R., P. R. Armstrong, K. K. Daellenbach, J. E. Dagle, F. V. Di Massa, D. B. Elliott, J. M. Keller, E. E. Richman, S. A. Shankle, G. P. Sullivan, and R. R. Wahlstrom. 1992b. Fort Drum Integrated Resource Assessment, Volume 3: Resource Assessment. PNL-8424 Vol. 3, 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

LIFE-CYCLE COST METHODOLOGY

APPENDIX

LIFE-CYCLE COST METHODOLOGY

According to the provisions of 10 CFR Part 436,¹ 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).² 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 LCC of the project from a similarly constructed LCC of the baseline. (The baseline is represented by the 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 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 Federal Energy Management Program (FEMP) model approach for federal energy efficiency using the FEDS (Facility 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 energy resource opportunities (EROs) identified by the FEDS assessment and described in the Volume 3 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."³ 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 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 CY 1993).
- 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 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.

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 order 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, and 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 the development and design of projects generally requires a detailed facility audit. Such a detailed audit is beyond the scope of, but will benefit from the guidance provided by, a FEDS assessment.

REFERENCES

1. 10 CFR Part 436. 1990 U.S. Department of Energy. "Federal Energy Management and Planning Programs." (Revision as of January 1, 1990.) U.S. Code of Federal Regulations.
2. U.S. Department of Commerce, National Bureau of Standards (NBS). November 1987. Life-Cycle Costing Manual for the Federal Energy Management Program. NBS Handbook 135, Prepared for Federal Energy Management Program Staff Office, U.S. Department of Energy. U.S. Government Printing Office, Washington, D.C.
3. 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.

DISTRIBUTION

No. of
Copies

No. of
Copies

OFFSITE

12 DOE/Office of Scientific and
Technical Information

J. Corriveau
Fort Drum, NY 13602-5097
ATTN: AFZS-EH-OM

D. A. Fournier
U.S. Corps of Engineers
Construction Engineering
Research Laboratory
P.O. Box 4005
Champaign, IL 61820-1305

5 A. Gillespie
FORSCOM
Building 200
Fort McPherson, GA 30330-6000
ATTN: FCEN-RDF

M. Ginsberg
Federal Energy Management
Program
U.S. Department of Energy
CE-44
1000 Independence Avenue SW
Washington, DC 20585

2 L. Harris
Federal Energy Management
Program
U.S. Department of Energy
CE-44
1000 Independence Avenue SW
Washington, DC 20585

V. Petrolati
DOE/In-House Energy Management
U.S. Department of Energy
1000 Independence Avenue SW
Washington, DC 20585

2 S. Rowley, Energy Manager
Fort Drum, NY 13602-50975
ATTN: AFZS-EH-OM

G. Greene
Fort Drum, NY 13602-5097
ATTN: AFZS-EH-OM

B. H. Starling
U.S. Army Corps of Engineers
Engineering Division
P.O. Box 1600
Huntsville, AL 35807-4301
ATTN: CEHND-PM-CR

ONSITE

DOE Richland Operations Office

D. D. Green, K8-50

51 Pacific Northwest Laboratory

P. R. Armstrong, K5-08 (4)
D. R. Brown, K8-18
J. W. Currie, K8-54
K. K. Daellenbach, K8-17
J. E. Dagle, K5-20
F. V. Di Massa, K8-18
J. A. Dirks, K8-18
D. R. Dixon, K8-17, (10)
D. L. Hadley, K5-08
M. A. Halverson, K5-08
J. M. Keller, K5-08
L. L. Larson, K8-18
G. B. Parker, K8-54 (5)
D. R. Payson, K7-90
R. W. Reilly, K8-54
E. E. Richman, K5-08

No of
Copies

T. J. Secrest, K5-02 (5)
S. A. Shankle, K8-15
D. J. Stucky, K8-15
G. P. Sullivan, K8-18
R. F. Szydlowski, K5-08

No. of
Copies

R. R. Wahlstrom, K5-08
L. E. Wrench, K5-08
Project File (2)
Publishing Coordination
Technical Report Files (5)

END

**DATE
FILMED**

11/29/93