UFC 3-401-05N
16 January 2004

UNIFIED FACILITIES CRITERIA (UFC)

ESTIMATING ENERGY AND WATER CONSUMPTION FOR SHORE FACILITIES AND COLD IRON SUPPORT FOR SHIPS

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

UNIFIED FACILITIES CRITERIA (UFC)

ESTIMATING ENERGY AND WATER CONSUMPTION FOR SHORE FACILITIES AND COLD IRON SUPPORT FOR SHIPS

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	**Date**	**Location**
1	Dec 2005	FOREWORD

This UFC supersedes Military Handbook 1133, dated September 1999.

FOREWORD

\1\
The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD(AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Support Agency (AFCESA) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request (CCR). The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current. /1/

AUTHORIZED BY:

DONALD L. BASHAM, P.E.
Chief, Engineering and Construction
U.S. Army Corps of Engineers

DR. JAMES W WRIGHT, P.E.
Chief Engineer
Naval Facilities Engineering Command

KATHLEEN I. FERGUSON, P.E.
The Deputy Civil Engineer
DCS/Installations & Logistics
Department of the Air Force

Dr. GET W. MOY, P.E.
Director, Installations Requirements and Management
Office of the Deputy Under Secretary of Defense (Installations and Environment)

CONTENTS

CHAPTER 1

INTRODUCTION

1-1 **PURPOSE AND SCOPE**. This UFC is comprised of two sections. Chapter 1 introduces this UFC and provides a listing of references to other Tri-Service documents closely related to the subject. Appendix A contains the full text copy of the previously released Military Handbook (MIL-HDBK) on this subject. This UFC serves as criteria until such time as the full text UFC is developed from the MIL-HDBK and other sources.

This UFC provides general criteria for estimating energy and water consumption for shore facilities and cold iron support for ships.

Note that this document does not constitute a detailed technical design, and is issued as a general guide to the considerations associated with estimating energy and water consumption for shore facilities and cold iron support for ships.

1-2 **APPLICABILITY**. This UFC applies to all Navy service elements and Navy contractors; Air Force service elements should use the references cited in paragraph 1-3 below; all other DoD agencies may use either document unless explicitly directed otherwise.

1-2.1 **GENERAL BUILDING REQUIREMENTS**. All DoD facilities must comply with UFC 1-200-01, *Design: General Building Requirements*. If any conflict occurs between this UFC and UFC 1-200-01, the requirements of UFC 1-200-01 take precedence.

1-2.2 **SAFETY**. All DoD facilities must comply with DODINST 6055.1 and applicable Occupational Safety and Health Administration (OSHA) safety and health standards.

NOTE: All **NAVY** projects, must comply with OPNAVINST 5100.23 (series), *Navy Occupational Safety and Health Program Manual*. The most recent publication in this series can be accessed at the NAVFAC Safety web site: www.navfac.navy.mil/safety/pub.htm. If any conflict occurs between this UFC and OPNAVINST 5100.23, the requirements of OPNAVINST 5100.23 take precedence.

1-2.3 **FIRE PROTECTION**. All DoD facilities must comply with UFC 3-600-01, *Design: Fire Protection Engineering for Facilities*. If any conflict occurs between this UFC and UFC 3-600-01, the requirements of UFC 3-600-01 take precedence.

1-2.4 **ANTITERRORISM/FORCE PROTECTION**. All DoD facilities must comply with UFC 4-010-01, *Design: DoD Minimum Antiterrorism Standards for Buildings*. If any conflict occurs between this UFC and UFC 4-010-01, the requirements of UFC 4-010-01 take precedence.

1-3 **REFERENCES**. The following Tri-Service publications have valuable information on the subject of this UFC. When the full text UFC is developed for this subject, applicable portions of these documents will be incorporated into the text. The designer is encouraged to access and review these documents as well as the references cited in Appendix A.

1.	U.S. Air Force	**AFETL 94-4**, Energy Usage Criteria for Facilities in the Military Construction Program, 19 August 1994 **AFETL 98-4**, Building Manager Energy Conservation Handbook, 16 January 1998

APPENDIX A

MIL-HDBK 1133
ESTIMATING ENERGY AND WATER CONSUMPTION FOR SHORE FACILITIES AND COLD IRON SUPPORT FOR SHIPS

INCH-POUND

MIL-HDBK-1133
30 September 1999

SUPERSEDING
MO-303
1 May 1972

DEPARTMENT OF DEFENSE
HANDBOOK

ESTIMATING ENERGY AND WATER CONSUMPTION FOR SHORE FACILITIES AND COLD IRON SUPPORT FOR SHIPS

THIS HANDBOOK IS FOR GUIDANCE ONLY. DO NOT CITE THIS DOCUMENT AS A REQUIREMENT.

AMSC N/A AREA FACR

ABSTRACT

This handbook is intended as a tool for appropriately estimating current and future energy consumption attributable to buildings, ships, and other energy uses at Navy installations. It presents a suggested energy allocation methodology and provides calculation assistance in a straightforward, easy-to-apply manner. The collection of building or ship characteristics data required to use this methodology is at a minimum to ensure easy, time-effective application. The resulting energy estimates are considered as applicable as other nonmetering estimating methods requiring much more detailed data collection and calculation.

FOREWORD

The original version of this manual, MO-303, Utilities Target Manual was last printed in 1972 as a utilities target manual for energy efficient facilities, and cold iron support for ships based on design conditions. The manual was developed prior to the oil embargoes of the late 70's, and there was little interest in metering tenant commands. As energy consumption became more of a concern, Navy tenant and Public Works Centers and Departments (PWC/Ds) became more concerned with tenant consumption. PWC/Ds began installing steam trunk line, and electricity meters at the building level. Tenant consumption estimates were developed using American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. (ASHRAE) fundamentals, MO-303, and initially limited base level metering. By derivation, these utility consumption estimates were based on primarily ideal conditions with some metered data to support it.

More recently PWCs developed software to more fairly distribute the cost of utilities on a base. The software CUBIC, UUS, NASSAU, and PWMA are of particular note in the Navy. This software estimates consumption to varying degrees, using recent building construction and use, ASHRAE based methods, and are coupled with some metered data to more fairly estimate tenant consumption. The software tools given in the table below are examples of those that can be used to varying degrees, to develop consumption estimates for unmetered facilities.

Software Tools for Utilities Consumption Allocation

AGENCY	**SOFTWARE**	**POC**
Department of Energy	DOE2	DOE FEMP office
	ASEAM	DOE FEMP office
	FEDS	DOE FEMP office
Navy	CUBIC	Naval Facilities Engineering Service Center
	UUS	Puget Sound Naval Shipyard
	NASSAU	PWC Pensacola
	PWMA	NAVFAC Headquarters
Private Industry	MAXIMO/PSDI TRACE	Trane Company

OPNAVINST 4100.5, Energy Management directed that all utility bills be based on metered data. The level of metering is left open for interpretation. Since metering all utilities at all buildings is not cost effective, we updated MO-303, based on a limited statistical sampling of metered data, by building type. MO-303 presented mathematical formulas, based on the sampled data, for estimating utility consumption. This new manual is based on sound mathematical principles and is a defendable approach. It is an inexpensive, simple approach that is best applied base wide rather than to only select consumers. We do not expect its estimates to necessarily match metered data or other estimating tools. If more accurate estimates are desirable and affordable, we recommend installing meters, and modeling unmetered buildings using software.

There is no one method of utilities estimating that meets all needs. The important thing is for public works agencies and tenant commands to agree on what cost effective methods should be used to allocate utility consumption on their base. Consider this update of MO-303 another tool for your use when metered data and software modeling is not cost effective or available.

Recommendations for improvement are encourage from within the Navy, other Government agencies, and the private sector and should be furnished on the DD Form 1426 provided inside the back cover to Commanding Officer, Naval Facilities Engineering Service Center, 1100 23rd Avenue, Port Hueneme, CA 93043-4370; phone commercial (805) 982-1693.

DO NOT USE THIS HANDBOOK AS A REFERENCE IN A PROCUREMENT DOCUMENT FOR FACILITIES CONSTRUCTION. IT IS TO BE USED IN THE PURCHASE AND PREPARATION OF FACILITIES PLANNING AND ENGINEERING STUDIES AND DESIGN DOCUMENTS USED FOR THE PROCUREMENT OF FACILITIES CONSTRUCTION (SCOPE, BASIS OF DESIGN, TECHNICAL REQUIREMENTS, PLANS, SPECIFICATIONS, COST ESTIMATES, REQUEST FOR PROPOSALS, AND INVITATION FOR BIDS). DO NOT REFERENCE IT IN MILITARY OR FEDERAL SPECIFICATIONS OR OTHER PROCUREMENT DOCUMENTS.

ESTIMATION OF ENERGY AND WATER CONSUMPTION FOR
SHORE FACILITIES AND COLD IRON SUPPORT FOR SHIPS

CONTENTS

APPENDICES

FIGURES

TABLES

Section 1: INTRODUCTION

1.1 Scope. This handbook is intended as a tool for appropriately estimating current and future energy and water consumption attributable to buildings, ships, and other uses at Navy installations. It presents a suggested allocation methodology and provides calculation assistance in a straightforward, easy-to-apply manner. The collection of building or ship characteristics data required to use this methodology is at a minimum to ensure easy, time-effective application. The resulting energy and water estimates are considered as applicable as other nonmetering estimating methods requiring much more detailed data collection and calculation.

The best consumption value for use in current or future energy and water tracking or assessment is one that is read from an accurate, operating, correctly placed meter. In some cases, these metered consumption values are available for a selected subset of buildings, ships, or processes. In other cases, consumption estimating methods vary from simple apportionment of consumption by square footage to elaborate manipulation of building construction, equipment, weather, and operations data. The methodology and assistance presented in this handbook are designed to provide estimated energy and water consumption values that are as accurate as possible without computer modeling of buildings or extensive building data collection. The methodology is not intended to be used to second-guess expected consumption when metered data exists. It is also not intended to replace an existing methodology that is effective and reasonably accurate. The methodology and assistance provided in this handbook are intended to be available for use where other systems are ineffective or outdated.

1.2 Methodologies. The calculation assistance is presented as a simplified yet reasonably accurate manner of assigning a first-level estimate of consumption values to various energy or water-using components. The assistance is presented primarily for energy and water use in buildings and ships. This involves assigning an initial energy or water consumption value per square foot for buildings and per ship class. This value is then further converted or adjusted based on fuel type, weather, and other characteristics, to arrive at a reasonable initial estimate that is consistent with all other initial estimates. These initial values and adjustments are derived from existing metered consumption data from buildings, groups of buildings and ships, entire Navy installations throughout the world, and other recognized ship and building energy consumption data sources. This data has been analyzed and reconciled to known consumption levels to arrive at values that are considered as accurate as possible for a typical building, ship, or process. Assistance is also provided for other nonbuilding energy uses.

Other methods of arriving at energy or water consumption values are available and used by design professionals, engineers, architects, and energy managers. These methods tend to be classical energy use aggregation models in which estimated consumption is summed from individual estimates of energy using equipment such as heating, cooling, water heating, and lighting. Many methods use standard thermodynamic calculations or calculation methods prepared and offered by organizations such as ASHRAE. The predecessor to this manual - Naval Facilities Engineering Command (NAVFAC) MO-303, relied on elements of this type of method. In general, an assessment of energy consumption with these methods requires large amounts of detailed data for each building. Experience has shown that the additional efforts required for these methods (over simpler methods based on historical actual consumption data) do not consistently provide more accurate estimates for existing military building energy usage. However, if an activity has relied on these methods and already collected the large amounts of data needed, then its continued use may be warranted.

The allocation methodology described in this handbook allocates total known energy or water use (usually utility billings) to various buildings, ships, and processes independent of the type of calculations used to estimate initial individual energy consumption. This method uses the initial consumption estimates derived for each building, ship, or process to apportion the total installation energy and water consumption equitably among users. It accounts for nonbuilding use such as line losses, street lights, and energy production that may not be applicable to building consumption as well as actual metered consumption and other known quantities. This method reconciles entire installation consumption such that all energy and water is equitably accounted for. It is an integral part of the process used to derive accurate estimates of energy and water consumption among groups of buildings, ships, or processes where actual metered data does not exist.

The allocation methodology and calculation assistance presented here are intended to be used to estimate individual energy and water consumption as reconciled to total installation consumption. In this system, initial individual estimates are adjusted (equally among individual estimates) to account for total installation consumption. This methodology is not intended to be used to estimate consumption for single buildings where no other data exists. Use of the data and methodology for this purpose is not considered accurate.

1.3 Handbook Organization. Section 2 of this handbook provides calculation assistance in identifying an initial energy use estimate for buildings, ships, and other energy uses. It includes initial energy consumption values and provides adjustment factors for use in revising the initial value to one that is more applicable to your installation.

Section 3 presents an energy allocation methodology for reconciling total installation energy consumption to the various metered data, as well as to estimates for each building, ship, or process. This method addresses nonbuilding consumption such as line losses, water and sewer, and other identifiable consumption that would not normally be attributable to buildings, ships, and processes.

Section 4 provides calculation assistance and allocation methodology for reconciling total installation water consumption to metered data and estimates for each building, ship, or process.

1.4 Cancellation. This handbook, MIL-HDBK-1133, dated 30 September 1999, cancels and supersedes MO-303, dated 1 May 1972.

Section 2: ENERGY CONSUMPTION ESTIMATION

2.1 Data Collection. The initial estimate of energy consumption (when no metered consumption data is available) is an important first step in assigning total energy consumption to individual buildings, ships, and other energy uses. This section describes how to make those initial estimates for buildings and ships. It also provides guidance for estimating other nonbuilding energy uses such as those for street lights, water and sewer systems, and produced energy such as electric generation, processes, and distribution losses. For buildings, the values include energy use intensities (EUIs) expressed in kilowatt-hours per square foot per month ($kWh/ft^2/mo$) or thousand British thermal units per square foot per month ($kBtu/ft^2/mo$) (or, in SI units, thousand joules per square meter per month [$kJ/m^2/mo$]). The appropriate value for ship energy use is the hourly use rate, expressed in kilowatt-hours (kWh) or thousand British thermal units per hour (kBtu/h) (or, in SI units, thousand joules per hour [kJ/h]).

A preliminary step in assessing energy use for an entire installation or a few buildings is to collect basic building and installation data. The following steps describe the process of gathering this information.

NOTE
This process can be done manually or with any spreadsheet or database software. Using a spreadsheet or database is strongly recommended and will provide faster and easier calculation.

a) All building energy assessments require three related data items. These are the cooling degree-days ≥ 65 degrees F (18 degrees C) [CDD(65)], heating degree-days ≤ 65 degrees F (18 degrees C) [HDD(65)], and wet-bulb hours ≥ 73 degrees F (23 degrees C) [WBH(73)]. The values for these items should be derived from actual current data wherever possible. If current data is not available, a 30-year average (readily available) can be used for annual estimates. These values should be expressed in monthly or annual values, depending on the time period of billing or use-estimation being considered. This data should be available in NAVFAC P-89, Engineering Weather Data for Design and Construction, or from the installation weather office or local airport.

b) Collect appropriate information from Naval Facilities Assets Data Base (NFADB), NAVFAC P-78, Navy Facilities Assets Data Base Management System Procedures Manual, or similar Real Property database sources, FACSO RPT 11016/R4640R01, Navy Real Property - Class 1 and 2: Detail, for all buildings to be included in the estimation. The information to be collected and a suggested format in which to record it are exemplified in Table 1. Each building or group of similar buildings must be assigned a building type to determine the appropriate building EUI values to be used. Building type can be based on knowledge of the building function. It can also be determined using the five-digit Navy real property category code. Table A-1 in Appendix A includes descriptions of the buildings represented by each building type. Table A-2 lists the Navy category codes considered to be applicable to each building type. If the information in these tables is used, the category code currently assigned to each building must accurately identify the true current use of the building. If it does not, another code should be assigned. For buildings or category codes (includes building types in Table A-3) that do not match one of the building types listed in Tables A-2 and A-3, a set of energy use values will need to be developed manually by the user based on other historical or engineering information for use in later calculations. Buildings with more than one significant use area can be subdivided and categorized separately by assigning the appropriate square footage to applicable building types. Spaces normally associated with a building type (for example, conference rooms and breakrooms in administration buildings) need not be accounted for separately.

c) For each building or group of similar buildings detailed in Table 1, a group code is created by combining the codes in the domestic hot water (DHW), cooled, and heat fuel columns. These group codes are used later to combine buildings with similar energy use. Other reasons, if any, for grouping buildings can be added to the group code. Possible additional items may include activity, reimbursable status, or utility billing meter.

The information collected in each step listed above should be recorded as accurately as possible, as it forms the basis for all other building energy use calculations.

Table 1
Facility Data From Real Property Data Sources

Bldg No.	Category Code	Bldg Type	Area ft^2	Elec. Metered (Y/N)	Fossil Fuels Metered (Y/N)	DHW Fuel (a)	Cooled? (Y/N)	Heat Fuel (a)	Group (b)
1	14140	ADMIN	50,000	N	N	E	Y	FNG	E-Y-FNG
2		BRK	25,000	Y	N	FNG	Y	FNG	FNG-Y-FNG
3		FH	1,200	N	N	E	Y	EHP	E-Y-EHP
4		ADMIN	200,000	N	N	E	Y	FNG	E-Y-FNG
6		FH	1,500	N	N	E	Y	EHP	E-Y-EHP
7		SHOP	50,000	N	Y	FNG	N	FNG	FNG-N-FNG

Notes:
(a) Fuel type abbreviations are as follows:
E = electric
ER = electric resistance heat (e.g., baseboard, forced air, radiant)
EHP = electric heat pump heat
FNG = fossil fuel - natural gas
FFO = fossil fuel - fuel oil
FS = fossil fuel - steam
FO = other fossil fuel (e.g., propane, hot water, coal, wood)
F = any fossil fuel
NH = no heat
(b) Group is a code used to group similar buildings by the domestic hot water (DHW) fuel type, presence/absence of cooling, and heating fuel type. This field is simply the previous three fields combined.

2.2 Building Energy. On Navy installations, buildings often constitute a major consumer of energy. For this reason, the estimate of building energy consumption must be as accurate as possible to develop reliable energy consumption information for each Navy installation. Energy consumption by buildings is expressed in terms of energy per unit area per unit time. In this handbook energy metrics used are as follows:

a) Electricity use is expressed in kilowatt-hours per square foot per month (kWh/ft^2/mo) (in SI units, this is kilowatt-hours per square meter per month [kWh/m^2/mo]).

b) British thermal units per square foot per month (kBtu/ft^2/mo) (in SI units, this value is expressed in thousand joules per square meter per month [kJ/m^2/mo]).

These EUI values are derived from actual metered energy consumption data collected at building and overall installation levels. Table B-1 in Appendix B contains the EUI values and other adjustment factors for Navy buildings. These EUIs are used to determine initial energy use values for each building or group of buildings. Tables 2 and 3 provide examples of the data to be gathered and calculations to be performed for building electric and nonelectric energy consumption.

2.2.1 Electric. The following steps define the process for estimating electrical building energy consumption using the forms shown in Tables 2 and 3.

a) Enter all metered building data (from utility or installation meter readings) onto the Table 2 form. Subtotal the energy consumption by building type. The values account for all known building energy use and need not be estimated. If metering equipment or readings are known to be inaccurate, the associated building energy use should not be included here. A total consumption estimate for metered buildings can be made by totaling all building type totals.

b) For buildings where metered data is not available, subtotal the square footage in the real property database by Bldg. Type and Group. Enter the Bldg. Type, Group, and Area in the Table 3 form. Enter the three weather parameters in the appropriate cells.

c) For each nonmetered Bldg Type and Group identified on the Table 3 form, find the corresponding EUI in the Electric Misc. EUI column in Table B-1 of Appendix B and enter that value on the Table 3 form.

d) Similarly, find the appropriate DHW EUI (if electric) and enter it on Table 3 form.

e) If the building is cooled, find the appropriate CDD(65) factor in Table B-1 and enter it on the Table 3 form along with the appropriate CDD(65) value. If it is a family housing building type, also add the appropriate WBH factor and WBH value.

f) If the building is heated electrically, find the appropriate Electric Heat factor in Table B-1 and enter it on the Table 3 form along with the appropriate HDD(65) value.

g) Sum the EUI portions to derive a total building type EUI.

h) Calculate the total consumption for each building type using the appropriate total area values. Total consumption for nonmetered buildings can be estimated by totaling all building type totals.

Table 2
Metered Building Electric Data

Bldg. Type	Bldg. No.	Area, ft^2	Electricity, kWh/month or year
BRK	2	25,000	40,125
...			
TOTAL			40,125

Table 3
Estimated Building Electric Data

Bldg. Type	Group	Misc. EUI	+	DHW EUI (a)	+	[CDD Factor (b)]	*	[CDD/ 1000]	+	[WBH Factor (c)]	*	[WBH /1000]	+	[Elec. Heat Factor (d)]	*	[HDD /1000]	=	Total Elec. EUI	*	Total Area, ft^2	=	Electricity kWh/mo (e)
ADMIN	E-Y-E	0.804		0.246		2.93		0.20		0		0		0		0		1.636		250,000		409,000
FH	E-Y-EHP	0.487		0.318		0.539		0.20		1.74		0.0250		0.777		0.0150		0.968		2,700		2,613
SHOP	F-N-F	0.397		0		0		0		0		0		0		0		0.397		50,000		19,850
TOTAL																						431,463

Notes:
(a) See first term in Group. If it is an E, then enter the electric DHW EUI from EUI Table; otherwise, enter zero.
(b) See second term in Group. If it is a Y, enter the CDD factor from the EUI Table; otherwise, enter zero.
(c) If the building type is FH, enter the WBH factor from the EUI table; otherwise, enter zero.
(d) See the third term in Group. If it is ER, enter the electric resistance factor. If it is EHP, enter the heat pump factor; otherwise, enter zero.
(e) If the calculation is being done on an annual basis, the Misc. and DHW EUI must be multiplied by 12.

2.2.2 Nonelectric. The following steps define the process for estimating nonelectric building energy consumption using the forms shown in Tables 4 and 5.

a) Enter all metered building data (from utility or installation meter readings) onto the Table 4 form. Subtotal the energy consumption by building type. This information accounts for all building energy use that is known and need not be estimated. If metering equipment or readings are known to be inaccurate, the associated building energy use should not be included here. A total consumption estimate for metered buildings can be made by totaling all building type totals.

b) For the buildings where metered data is not available, subtotal the square footage in the Real Property database by Bldg Type and Group. Enter the Bldg Type, Group, and Area, ft^2 in the Table 5 form. Enter the HDD(65) values in the appropriate cells.

c) For each nonmetered Bldg Type and Group, find the appropriate DHW EUI in Table B-1 of Appendix B and enter it on the Table 5 form.

d) If the building is heated (nonelectrically), find the appropriate HDD(65) factor and enter it on the Table 5 form along with the appropriate HDD(65) value.

e) Sum the EUI portions to derive a total building type EUI.

f) Calculate the total building type consumption using the appropriate total area values. A total consumption estimate for nonmetered buildings can be made by totaling all building type totals.

Table 4
Metered Building Nonelectric Data

Bldg. Type	Bldg. No.	Area, ft^2	Fossil Fuels, kBtu/month or year
SHOP	4	50,000	36,068
TOTAL			36,068

Table 5
Estimated Building Nonelectric Data

Bldg. Type	Group	DHW EUI (a)	+	[HDD Factor (b)]	*	[HDD /1000]	=	Total Nonelec. EUI	*	Area, ft^2	=	Nonelec. Total, kBtu/month (c)
ADMIN	E-Y-F	0		8.51		0.0150		0.127		250,000		31,750
FH	E-Y-EHP	0		0		0		0		2,700		0
BRK	F-Y-F	2.725		4.81		0.0150		2.797		25,000		69,929
TOTAL												101,679

Notes:
(a) If the first letter in the first term in Group is F, enter the nonelectric DHW EUI for the building type from the EUI table; otherwise, enter zero.
(b) If the first letter of the third term in Group is F, enter the nonelectric HDD modifier for the building type from the EUI table; otherwise, enter zero.
(c) If the calculation is being done on an annual basis, the DHW EUI must be multiplied by 12.

2.3 Ship Energy. Energy use by ships cannot generally be characterized in terms of square footage. Instead, that activity is characterized by the number of hours the ship is supplied by shore utility services. In this handbook, an hourly use rate, expressed in kilowatt-hours (kWh) or thousand

British thermal units per hour (kBtu/h) (or, in SI units, thousand joules per hour [kJ/h]), is used for ship energy use. In general, ships alongside the dock require two types of loads: maintenance/overhaul loads and hotel loads. In this handbook, most minor repair work not associated with a Naval shipyard (i.e., when the crew stays on board) is considered part of the hotel load.

2.3.1 Maintenance/Overhaul Loads. Maintenance and overhaul work is usually a combination of dockside and dry-dock operations during which the crew is off the vessel. This kind of energy use depends heavily on the type of work being performed and how this work is performed at each specific location; consequently, it is not easily quantified. At most installations, some means of estimating this energy is in place and must be considered the best available data.

2.3.2 Electric Hotel Loads. Electric hotel loads by ship class are shown in the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and Construction Criteria Base (CCB). For ships not included in the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and CCB, hotel load data must be derived by other means. If a similar ship (size, form, function) is listed in the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and CCB, the listed loads may be the best available data. The estimated energy consumption is calculated by multiplying the kilowatt load by the number of hours the ship received shore power. Electric demand is simply the kilowatt load, unless it is known that the ship was connected during only off-peak periods when no kilowatt consumption is billed.

2.3.3 Steam Hotel Loads. Steam hotel loads comprise the constant load required for ship systems (e.g., domestic hot water, galley, laundry, boiler) and the intermittent (space heating) load. The ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and CCB present the steam loads by ship class. For ships not included in the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and CCB, use data from the table for a similar ship. The intermittent load is based on outdoor temperature; interpolation between temperature values may be required to match a specific location. An approximation of the appropriate outdoor temperature to use can be calculated as the HDDs for a period divided by the number of days in that period (typically a month). For additional accuracy, temperatures can be calculated in this manner for consecutive weeks or days and averaged over a month. Steam use is calculated by multiplying the sum of the constant and intermittent loads by the number of hours the ship received shore steam.

2.3.4 Metered Data. In many cases, a pier may be metered for electricity or steam but individual ships are not. If only one ship is at the pier, the metered data can be used to determine the consumption by the ship. More often, several ships are at the pier, all connected to a single meter. Using the data in the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and CCB, consumption can be prorated to the individual ships based on the metered total. Using actual metered data in this manner is always recommended over relying solely on the data from these tables.

2.3.5 Process for Estimating Ship Energy Consumption. The following steps define the process for estimating ship energy consumption using the forms shown in Tables 6 and 7. Related ship service energy associated with pier operation such as pier lighting, transformer losses, compressed air supply, and sewer/water pumps that are not separately metered or accounted for will be prorated to ships under this process. If this energy is not to be prorated to ships, it must accounted for as an additional line item in the reconciliation process (refer to pars. 2.4 through 2.8).

a) Enter all metered ship data on the Table 6 form. All that is required is the Ship Class/Name and the energy consumption. This data accounts for all ship energy use that is known and need not be estimated. If metering equipment or readings are known to be inaccurate, the associated ship energy use value should not be included.

b) For each nonmetered Ship Class/Name, find the Design Electric Load, kW in the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and CCB and enter it on the Table 6 form.

c) Similarly, find the appropriate Intermittent Steam and Constant Steam values from the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and CCB and enter them on the Table 7 form. The HDDs for a period divided by the number of days in that period (typically a month) can be used as an approximation of the appropriate outdoor temperature to use in finding the Intermittent Steam value. For additional accuracy, temperatures can be calculated in this manner for consecutive weeks or days and averaged over a month. If the calculated outdoor temperature falls between the temperatures in the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm, an interpolation will be required.

d) For each ship, obtain the Connect Hours from appropriate port or dock offices. Enter the hours for each ship on both Table 6 and 7 forms.

e) Calculate each ship's total consumption for electric and nonelectric use based on the connected hours.

f) Add any estimates for major maintenance and overhaul consumption to both the electric and nonelectric calculations. A total consumption estimate for all ships can be made by totaling all individual ship totals. Refer to MIL-HDBK-1025/2, Dockside Utilities for Ship Service for diversity factors use in determining demand in multiple berthing.

Table 6
Metered and Estimated Ship Electric Data

Ship Class/ Name	Connect Hours	*	Design Elec. Load, kW	=	Ship Electricity, kWh
CG-16	30		1,080		32,400
DD-931	10		1,150		11,500
CVN-68	40		5,990+5,760		470,000
TOTAL					513,900

Table 7
Metered and Estimated Ship Nonelectric Data

Ship Class/Name	Intermittent Steam, kBtu/h	+	Constant Steam, kBtu/h	=	Ship Steam Load	*	Connect Hours	=	Ship Steam Consumption, kBtu
CG-16	2.4		2		4.4		30		132
DD-931	1.5		1.2		2.7		10		27
CVN-68	13.4		6.7		20.1		40		804
TOTAL									963

2.4 Unusual Building Loads. In this handbook, unusual building loads are defined as loads associated with a building that are not considered a part of typical operations for that building type. These loads are found in two types.

The first type is operation of equipment or buildings in excess of typical conditions. This would include typical daytime buildings or systems operated 24 hours per day. The second type contains loads that are not considered typical functions in that building type. Examples include large printing equipment in a standard office building or swimming pool water circulation equipment included in a storage building. Neither of these load types is represented in the typical EUI values presented in this handbook and must be added as part of the whole-building EUI.

Loads defined as unusual will typically be found as motor loads, resistance electric loads, or process steam or hot water loads. Estimating these loads can be a straightforward calculation of operating rate or capacity multiplied by the hours of operation. However, in many cases the hours of operation are not well known. The rate or capacity of equipment can also be hard to identify accurately. In the case of constant loads such as strip heaters or single-level steam appliances, the nameplate rating expressed in energy per hour can be considered an appropriate value. For motors and other induction loads, the actual consumption rate value will depend on actual loading of the equipment. This loading will vary greatly and may be difficult to quantify. In most cases, the nameplate values will be a maximum that is not often achieved. Estimates of these unusual loads must be added to the total energy consumption value derived for the typical building with which it is associated. To estimate each load, the following steps can be used:

a) Identify the nameplate or other value of capacity. If part-load or other actual operational conditions that affect actual energy draw can be determined, they should be taken into consideration.

b) Determine the number of hours of operation.

c) Calculate consumption by multiplying consumption rate by time.

d) Add this value to the electric or nonelectric total as appropriate.

2.5 Street and Exterior Lighting. Street and exterior lighting is defined to be any exterior lighting other than that typically found around a building. Therefore, normal safety/security lighting (e.g., lighting over doorways and entrances; porch lights) is not typically considered exterior. Lighting in parking areas, security lighting, or floodlighting for outdoor work at night are typically considered exterior. The energy this lighting consumes is not usually assigned to specific buildings or activities and is often accounted for separately. The determination of whether this energy use is to be allocated among buildings or ships is left to each user and can be appropriately accounted for in the reconciliation process (Section 3). If reliable metering of exterior lighting is in place, this is considered the best source of an energy value. If partial or no metering is available, the method presented here can provide a reasonably accurate estimate.

2.5.1 Accountability. The level of detail at which this energy can be accounted for can vary depending on the amount of data available and the amount of effort expended in collecting additional data. In most cases, an accounting of the quantity and type of street lighting can be aided by maintenance personnel and lamp procurement records. These may provide information about the size and type of overhead lights that are inaccessible without special equipment. If outdoor lighting data is not available from maintenance or facilities sources, an inventory will be required. If possible, the information should be recorded on the basis of individual lamps as this will facilitate future energy use adjustments and demand calculations in connection with system expansions. The outdoor lighting loads should be defined by type, number of lights, rating, and, where applicable, kinds of use (intermittent or all night). Typical operating hours for most standard exterior lighting include the following:

a) Street lighting - average hours, sunset to sunrise.

b) Security lighting - average hours, sunset to sunrise.

c) Floodlighting of working areas - average hours, one hour before sunset to end of last working shift (or one hour after sunrise, whichever comes first).

d) Parking lot floodlighting - average hours, sunset to one-half hour after end of last working shift, plus duration of special events requiring evening use of parking lots (the base security office may keep records of such special off-hour uses).

Most outdoor lighting falls into the first two categories. For safety and security reasons, working area and parking lot lights are seldom extinguished and would therefore be considered security lighting. However, any lights that do operate on a less than all-night schedule should be noted on the lighting inventory. Steps should be taken to ensure that other special uses of significant outdoor lighting loads such as airfield and dockside lighting are recorded. Monthly sunrise and sunset times can be used to estimate the number of hours of darkness during any analysis period (i.e., monthly). On an annual basis, average hours, sunset to sunrise, will be 12 hours per day, 365 days per year.

Most high-intensity discharge (HID) lighting uses a ballast similar to fluorescent lighting. The ballast draws a certain amount of energy for its operation. This energy must also be included when calculating the total energy use for outdoor lighting. Table C-1 in Appendix C lists most of the different outdoor light types and typical combined lamp and ballast wattage. Note that Table C-1 does not include fluorescent lights. These are usually not used as exterior lighting as defined here. Fluorescent outdoor lighting is usually attached to the building and included in building energy consumption.

The outdoor lighting energy for each lighting type and hours of use is obtained by

$$E = \frac{N * P_r * H}{1000} \qquad (1)$$

where

E = energy consumption in kilowatt-hours
N = number of lamps of a given rating
P_r = lamp rating in watts (including any ballast)
H = illuminating hours per day with H adjusted to fit conditions at the activity as discussed above

2.5.2 <u>Process for Estimating Outdoor Lighting Operation</u>. The following steps define the process for estimating outdoor lighting operation using the form shown in Table 8:

a) Complete an inventory of lighting including lamp type, quantity, and hours of operation during the time period being considered.

b) For each lamp type and size, identify the total wattage draw from Table C-1 in Appendix C.

c) Calculate energy consumption per Equation 1.

d) Sum all energy consumption values to derive total installation exterior lighting consumption.

Table 8
Exterior Lighting Energy

Lamp Type	Count	*	Lamp + Ballast Wattage	*	Hours	/	1000 (W/kW)	=	Street lighting Energy, kWh
HPS 150	25		185		365		1000		1,688
MERC 400	40		454		365		1000		6,628
...							1000		
TOTAL									8,316

2.6 <u>Electric Transmission and Distribution Losses</u>. The transmission and distribution losses associated with all energy production and supply systems must be accounted for separately if an accurate allocation of energy is to be made. The determination of whether this energy use is to be allocated among buildings or ships is left to each user and can be appropriately accounted for in the reconciliation process. In some cases, analysis of these losses may already have been done by installation personnel or outside contractors. If these values are considered current, they may provide the best estimate of these losses. Estimated losses between 3 and 10 percent of total electricity consumption have been calculated at various military installations (Griffis Air Force Base Integrated Resource Assessment, Volume 2: Baseline Detail, Dixon et al., 1993; Vandenberg Air Force Base Integrated Resource Assessment, Volume 2: Baseline Detail, Halverson et al., 1993; Robins Air Force Base Integrated Resource Assessment, Volume 2: Baseline Detail, Kelleret al., 1993; Fort Irwin Integrated Resource Assessment, Volume 2: Baseline Detail, Richman et al., 1994). This can be a relatively small number compared to other energy uses. However, if an accurate value is desired, the methodology presented here can provide an estimate with a minimum of required data.

2.6.1 Transformer Losses. Most transmission and distribution system energy losses are due to transformer losses. Transformer energy loss consists of no-load and load power losses. No-load loss is the energy consumed by the transformer's magnetic field during periods when the transformer is energized. This loss is dependent on the device configuration and design, materials used, and power voltage and frequency. These characteristics remain constant during the loading cycle and, therefore, do not change with transformer load measured in kilovoltamperes (kVA). Load losses, on the other hand, are produced from resistance in the conductor windings. These losses are a function of the total transformer current and vary as a function of the square of the transformer load.

2.6.2 Transformer Loss Calculations. Transformer loss calculations include both the peak power demand and the annual energy consumption. This distinction is particularly important to assess the impact to the overall electrical consumption, because both demand and energy are billed separately. The peak transformer demand includes the no-load and load losses. Because transformer loss is a function of load, the maximum transformer loss is almost always coincident with the peak load consumed by the installation.

Table D-1 in Appendix D lists typical no-load and load losses for various transformer sizes taken from data contained in Electric Power Distribution System Engineering, Gönen, 1986. The load loss given in the table represents operation at full nameplate capacity, as measured in kVA.

NOTE

Although Table D-1 has value related to losses for older existing transformers, it is not accurate for transformers that the Navy has been procuring through NAVFAC guide specifications such as NFGS-16272, Three Phase Pad-Mounted Transformers. The no load losses derived from the NFGS are lower than those in Table D-1. The load losses for larger transformers derived from the NFGS are lower than those in Table D-1.

To calculate the total energy loss of the transformers, both the no-load and load contributions must be accounted for. The no-load energy consumption is the no-load loss multiplied by the number of hours in the time period under consideration. The load loss contribution must include the nature of part-loading on transformers as well as variations in the load.

2.6.2.1 Peak Load. Because the peak load normally differs from the transformer capacity given in Table D-1, the actual loss must be adjusted accordingly. Equation 2 gives the formula for calculating the demand loss factor (F_{DLS}) used to adjust the transformer loss during peak loading as opposed to nameplate capacity operation. Because the load loss is primarily resistive losses in the windings, this equation is based on the I^2R nature of resistive loss:

$$F_{DLS} = \left| \frac{\text{Peak Load (kW)} * \text{div. factor}}{\text{Nameplate Capacity(kVA)}} \right|^2 \qquad (2)$$

where

Peak Load (kW) = peak billed kilowatts from utility billing

Nameplate Capacity (kVA) = total installation transformer capacity
Division factor = 2.0

The diversity factor (ratio between the individual maximum demands and the coincident maximum demand) is applied at a value of 2.0 to all transformers based on the National Electric Code diversity factor allowances (The National Electrical Code Handbook: Based on the 1999 Edition of the National Electrical Code, Earley et al., 1999).

2.6.2.2 Load Variations. Variations in electrical consumption can exist hourly (within a 24-hour day), seasonally (primarily summer/winter), and by electrical feeder loading. These load variations affect actual losses and should be accounted for, if known. Seasonal, monthly, or feeder variations can be accounted for by calculating the various loading factors needed for this analysis for each season, month, or feeder. The 24-hour variations are generally constant for most energy use except cooling and are impractical to calculate for each separate day. Therefore, another factor (F_{LD}) accounts for the effects of daily load variations and the I^2R nature of the resistive loss, using the average and peak loads that are easily acquired from utility and installation sources. Equation 3 gives the formula for calculating this load factor. The equation is based on data developed in Gönen (1986).

$$F_{LD} = \text{Load Factor} = \frac{\text{Average Load (kW)}}{\text{Peak Load (kW)}} \tag{3}$$

where

Average Load (kW) = total utility billed kilowatts in billing period
Peak Load (kW) = peak billed kilowatts from utility billing

The (F_{LD}) and (F_{DLS}) factors are used to derive the energy loss factor (F_{ELS}) shown in Equation 4. This calculation combines the partial loading and load variation effects into one factor:

$$F_{ELS} = F_{DLS}(0.3\,F_{LD} + 0.7\,F_{LD}^{2}) \tag{4}$$

The equations for calculating the overall contribution of transformer losses to demand and energy consumption are given in Equations 5 and 6:

$$Demand\ Loss\ (Watts) = NLL + F_{DLS} * LL \tag{5}$$

$$Energy\ Loss\ (kWh) = hours(NLL + F_{ELS} * LL)/1000 \tag{6}$$

where

NLL = transformer no-load loss (watts) from Table D-1 in Appendix D
LL = transformer load loss (watts) from Table D-1 in Appendix D
hours = hours in the period being considered (month, year)

2.6.3 Process for Estimating Electric Transmission Losses. The following steps define the process for estimating electric transmission losses using the forms shown in Tables 9 and 10:

a) Identify the time period to be considered such as month, season, or year. Identify the peak load for that time period from the utility bill. Calculate the total nameplate capacity by summing the kVA rating of all transformers. Calculate the average load by dividing the total kilowatt-hours consumed by the total hours in the time period. Enter each of these values in Table 9.

b) From the values entered and derived in Step 1, calculate the (F_{DLS}), (F_{LD}), and (F_{ELS}) factors using Equations 2, 3, and 4 and enter on Table 9.

c) Enter No. of Phases, Voltage, Capacity, and No. of Units information for each transformer type in Table 10. For each transformer or group of transformers, find the appropriate Load Loss and No-Load Loss values in Table D-1 in Appendix D and enter on Table 10. If the transformer does not appear in the table, extrapolation can be used, or check with the manufacturer to determine the losses.

d) Using Equations 5 and 6, calculate the Energy Loss and Demand Loss for each transformer or group of transformers. Note: The example in Table 10 uses summer values and number of hours in one season.

e) Sum all transformer loss values to create total installation transformer energy and demand loss values.

Table 9
Electrical Transformer Loss Factors

Season/Month	Peak Load (KW)	Average Load (KW)	Total Nameplate Capacity (KVA)	Demand Loss Factor (F_{DLS})	Load Factor (F_{LD})	Energy Loss Factor (F_{ELS})
Summer	800	100	1225	1.706	0.125	0.0826
Winter	400	60	1225	0.426	0.150	0.0259

Table 10
Electrical Transformer Losses

No. of Phases	Voltage (Prim/Sec)	Capacity (kVA)	No. of Units	No-Load Loss (W)	Load Loss (W)	Energy Loss (kWh/month)	Demand Loss (W)
1	2400/240	25	3	118	304	940	1,910
1	7200/480	50	1	185	535	502	1,098
3	4160/208	150	4	560	1690	6,128	13,773
3	12,470/480	500	1	1600	5200	4,445	10,471
TOTAL						12,015	27,252

2.7 Water and Sewer Energy. Water and sewer energy includes the energy associated with potable water and sewage waste pumping, processing, and distribution. These services are usually installation-wide and either supplied under contract with others, operated by the installation facilities organization, or performed by some combination of these. Where the services are supplied under contract, there is no energy consumption to deal with in this process: the cost of the contract includes the energy component. Where these services are operated on the installation, an energy consumption value may need to be identified for energy accounting and allocation purposes.

2.7.1 Water Supply System. Typical water supply system may consist of well or reservoir pumps and booster or supply pumps. These pumps account for the vast majority of energy consumed by most water systems. The calculation of water supply energy generally involves calculating the energy use for multiple motors. Two primary calculation methods can be used, depending on the type of data available at the installation.

2.7.2 Calculation of Water Supply Energy. The first method applies when motor characteristics data and pump run hours are available. This information is often kept by the water supply department for water balancing and motor replacement purposes. In this case, a straightforward multiplication of motor energy consumption in kilowatts (kW) by time in hours provides a kilowatt-hours (kWh) value. Motor energy consumption depends primarily on motor horsepower (hp) capacity, efficiency, and loading. The motor capacity and efficiency can often be found on nameplates or from manufacturers' literature. National Electrical Manufacturers Association (NEMA) MG1, Motors and Generators, Table 12-10 provides typical motor efficiency values if actual efficiencies cannot be found. The efficiency will affect actual consumption beyond standard capacity ratings.

Motor loading is also known to affect actual motor energy consumption. However, this effect is usually noticeable only at loading below 50 percent and can be ignored for most water and sewer system motors. Equation 7 provides a calculation method when run hours are available:

$$\frac{motor\ capacity\ (kW)}{motor\ efficiency} * run\ hours = energy\ use\ (kWh) \qquad (7)$$

where motor capacity is in kW or horsepower multiplied by a conversion factor of 0.746.

If run hour data is not readily available, a less exact approach can be used. This approach involves applying data for total delivered gallons of water and gallon-per-minute (gpm) pump ratings to estimate run hours. At its roughest level, the total gallons of delivered water can be divided by the total gpm rating for all pumps to obtain average operating hours based on an average pump rating. Multiplying the operating hours value by the average pump motor capacity (kW) will provide an estimated water energy consumption. This process should be completed for as small a set of motors as possible where water use data exists. Using the smallest possible motor set will make the average pump motor capacity value as accurate as possible.

Care should be taken if booster pumps are in use. Because these pumps typically pump the same water again, their inclusion in the calculation of average operating hours will produce lower than actual pumping hour values. The energy use of these pumps should be calculated separately. Discussions with water supply personnel may also provide information on which pumps are used the most. Equation 8 provides a calculation method when run hours must be estimated.

$$\frac{ave.\ motor\ capacity\ (kW)}{ave.\ motor\ efficiency} * \frac{gallons}{60 gpm} = energy\ use\ (kWh) \qquad (8)$$

where

ave. motor capacity (kW) = average capacity of target set of motors
ave. motor efficiency = average capacity of target set of motors
gallons = total delivered gallons for target set of motors
gpm = average gpm rating for target set of pumps

2.7.3 Sewer Energy. Sewer processing energy is used in a variety of pumps and mixing motors as well as sewage booster pumps. Estimates of the energy use associated with the booster pumps can be calculated in a manner similar to that for the water supply estimate. Specific operating records for the processing pumps and mixing motors may not exist. However, most sewage processing is a 24-hour-a-day operation. Discussions with operating personnel may provide appropriate details, and motor efficiency and loading should be considered.

2.8 Miscellaneous Nonbuilding Loads

2.8.1 Exterior Communications. Exterior communication energy use usually associated with shore-to-ship operations is variable and therefore hard to quantify. Normal ship or building communication traffic will be included in estimates of typical ship and communications building electricity use. However, unusually heavy transmissions or continuous use may need to be assessed separately and added to appropriate ship or building consumption estimates. The estimate of these additional loads could be derived using the nameplate ratings on specific equipment, estimated hours of operation, and length of transmissions. The transmission length and number information should be available from a communications office where transmission information is kept.

2.8.2 Process Loads. Process loads such as production and ship/aircraft overhaul are also difficult to quantify. A preferred method of identifying process energy use is the use of short-term portable metering (day or week) of selected processes as a baseline for energy consumption. If this is not practical, the loads can be estimated by identifying the equipment in use, its actual energy draw (from nameplate or spot metering), and operating characteristics.

2.8.3 Steam and Hot Water Distribution Losses. Steam and hot water distribution losses are not included as part of initial building energy use values in this handbook. If distribution losses are to be apportioned throughout all buildings that use this energy, then calculation of losses is not specifically required for a final reconciliation of all installation energy. The energy will be apportioned to the buildings as part of the reconciliation process. However, a method is presented here to separately assess this energy if needed.

The method involves an assessment of system plant loading during no-use hours. The best times to use for this estimate are those when there is no heating load and virtually no hot water consumption. This would typically occur on a warm weekday summer night between 1 a.m. and 4 a.m. Also, consider an appropriate time in the spring prior to summer shutdowns and a time in the fall shortly after winter startup. Plant operating records that indicate steam or hot water supply temperatures and flows during these times can be used to assess losses. During no-use periods, the amount of fluid cycled and associated supply and return temperatures should be collected. Generally, the more periods of data collected and used, the more accurate the estimate. The difference in temperatures (assuming constant pressure) can be used with any standard steam table to determine an estimated heat loss per quantity of fluid. This value multiplied by the fluid cycled will provide an estimate of heat losses per hour. This method must assume the accuracy of the flow and temperature measurements. Any condensate return in steam systems must also be accounted for. Equation 9 can be used to calculate estimated losses from steam and hot water systems:

$$Loss\text{-}rate = \frac{[E_{supp} * Flow_{supp}] - [E_{ret} * Flow_{ret}]}{1000} \qquad (9)$$

where

- Loss-rate = estimated line loss rate in kBtu/h
- E_{supp} = enthalpy of steam OR hot water flow at exit temperature in Btu/lb
- $Flow_{supp}$ = flow rate of supply fluid in lb/h
- E_{ret} = enthalpy of condensate OR hot water flow at return temperature in Btu/lb
- $Flow_{ret}$ = flow rate of return fluid in lb/h

The loss rate value can then be multiplied by the plant operating hours for the time period being analyzed, to derive an estimated loss value.

2.8.4 Central Plant Efficiency. Central plant efficiency is another energy use that is not accounted for in building estimates. As with line losses, if this energy is to be allocated to buildings, it need not be calculated. However, if this energy use is to be accounted for separately, it may be estimated. Plant efficiency is a combination of other component efficiencies such as combustion, transfer losses, and auxiliary load uses. Assessments of large central plant operations and efficiencies may have been done recently at the installation by installation or contractor staff. This information provides the best values and is the preferred method. If these assessments have not been done recently, the operations staff may roughly estimate efficiency by dividing the thermal content of fuel used by the thermal content delivered.

2.8.5 Energy Transfers Off the Installation. Energy transfers off the installation do not necessarily require any calculation unless the quantities are unknown. This energy transfer is discussed here because it is important that it be included in any total installation reconciliation. If any raw fuel or energy produced on the installation is transferred off the installation, it must be accounted for in raw fuel quantities. The efficiency of its production or distribution is not important to total installation reconciliation so long as the raw fuel consumption is billed to others and not assumed as a cost to the installation.

Section 3: ENERGY CONSUMPTION DATA RECONCILIATION

3.1 Scope. Reconciliation of all estimated (or metered) energy consumption data with the total actual consumption (installation, feeder, metering point) is as important to accurate energy allocation as the assignment of an initial EUI. The reconciliation accounts for inaccuracies in the EUI value assignments by forcing the sum of all estimated and metered values to equal the total actual (billed) consumption. If all initial estimates are based on similar assumptions and estimation techniques, the reconciled values can be considered equitable among each other.

Reconciliation may be performed at various levels and/or sections of an installation as well as the overall installation. A complete reconciliation incorporates all energy use for an area or installation including buildings, ships, processes, street lights, losses, and other nonbuilding uses. Most Navy installations have some sort of reconciliation process. If the process currently in place provides accurate, repeatable, and equitable results, there may be no need to revise or replace it. However, if an installation's process is either nonexistent or nonfunctional, then part or all of the process presented here should be considered.

NOTE
This process can be done manually or with any spreadsheet or database software. Using a spreadsheet or database is strongly recommended and will provide faster and easier calculation.

3.2 Reconciliation Process. The process described here involves inputs of estimated and known energy use. The calculation assistance presented in Section 2 can be used to prepare many of the inputs required. The forms and sample reconciliation displayed in Tables 11 through 16 were completed by following these steps:

a) Define a consumption period and group of buildings and/or other energy uses (e.g., one-month time period and entire installation).

b) Collect and enter the total billing (usually utility metered) consumption values for all fuels for that time period in Table 11as Billed Totals. It is important to verify that these values relate directly to the group of buildings and other energy uses under consideration as well as to the appropriate time period being considered.

c) Identify all metered and otherwise known energy consumption quantities for buildings, ships, and other processes. Include these quantities in Table 11 for all fuels.

d) In the appropriate component spaces, enter estimated total consumption values for buildings and ships that are not metered. Refer to Section 2 for calculation assistance.

e) Evaluate all miscellaneous energy use components such as distribution losses, street lights, and other nonbuilding loads. For each energy use, identify an estimated consumption value by the best available method (refer to Section 2). Include these values in Table 11.

f) Sum the energy component estimates and known consumption for each fuel to derive the Estimated Total. Compare these to the Billed Total consumption values entered in Step (b). If any of the summed totals do not match, an adjustment or correction is required.

If the difference is within 20 percent, it can be considered reasonably accurate, given the many variables affecting energy use. Major calculations and assumptions should be rechecked for potential errors if the difference exceeds 20 percent. If errors are found or revisions to assumptions are appropriate, the reconciliation should be recalculated with new values. Any remaining difference may be attributable to weather and operational factors that vary from installation to installation and are not always accurately represented by the estimation process.

g) The final reconciliation step eliminates any remaining difference between the actual total consumption and the summed estimates and metered values. This difference is apportioned to energy use components by a percentage Adjustment Factor calculated in Table 11. The Adjustment Factor is determined by dividing the Difference (Billed - Estimated) by the sum of selected Energy Use Components to which the difference is to be apportioned (see equation in Table 11). For example, if the difference is to be apportioned among all estimated (nonmetered) buildings and ships, then the factor is the difference divided by the sum of all Estimated Building Energy and Estimated Ship Energy.

h) The Adjustment Factor value calculated in Table 11 is then multiplied by each of the selected Energy Use Components to derive new estimates. These new values are reinserted in the process (Table 11) and retotaled. At this point, the totals should closely match, and all values should be checked to ensure they are complete and reasonable.

The energy components that are adjusted by Steps (g) and (h) should be those with the lowest level of confidence and, therefore, the greatest possible variance from actual use. In most cases, these will be the estimates for buildings and ship use.

i) The final step is the adjustment of the individual building estimates within each energy use component used to derive the adjustment factor. Tables 13 through 16 show a sample adjustment for buildings and ships. In each case, the adjustment factor is applied to each of the individual building groups or ship classes/names to proportionally distribute the difference calculated in Table 11. The new total values in Tables 13 through 16 should match the adjusted component values in Table 12.

Table 11
Total Energy Reconciliation

Energy Use Component	Electricity, kWh	Natural Gas, kBtu	Fuel Oil, kBtu	(b)
Metered Building Energy	40,125	73,120		
Estimated Building Energy	431,463	101,679		
Metered Ship Energy	0	0		
Estimated Ship Energy	513,900	963		
Elec. Trans. & Dist. Losses	4,005	0		
Central Plant Efficiency & Dist. Losses	5,000	1,000		
Street and Exterior Lights	8,316	0		
Process Energy	0	0		
Water and Sewer Energy	25,000	0		
Exterior Communications	12,000	0		
Energy Transfers to Off-Site	0	0		
Misc. Other Energy Use (not assoc. with above)	0	0		
ESTIMATED TOTAL:	1,039,809	176,762		
BILLED TOTAL:	1,254,650	163,000		
Difference (Billed - Estimated):	214,841	-13,762		
Adjustment Factor (a):	1.227	0.866		

(a) "Adjustment Factor" = [1+(Difference (billed - Estimated)/sum of selected Energy Use Components)]. The selected Energy Use Components are those energy use areas to which the reconciliation difference is to be allocated. In this example, selected components are estimated building energy and estimated ship energy.

(b) Data for other fuel types are entered into additional columns.

Table 12
Adjusted Total Energy Reconciliation

Energy Use Component	Electricity, kWh	Natural Gas, kBtu	Fuel Oil, kBtu	(b)
Metered Building Energy	40,125	73,120		
Estimated Building Energy	529,405	88,054		
Metered Ship Energy	0	0		
Estimated Ship Energy	630,555	834		
Elec. Trans. & Dist. Losses	4,005	0		
Central Plant Efficiency & Dist. Losses	5,000	1,000		
Street and Exterior Lights	8,316	0		
Process Energy	0	0		
Water and Sewer Energy	25,000	0		
Exterior Communications	12,000	0		
Energy Transfers to Off-Site	0	0		
Misc. Other Energy Use (not assoc. with above)	0	0		
ESTIMATED TOTAL:	1,254,406	163,008		
BILLED TOTAL:	1,254,650	163,000		
Difference (Billed - Estimated):	244	-8		
Adjustment Factor:	1.000	1.000		

Table 13
Building Electricity Use Adjustment

Bldg. Type	Group	Total Electric EUI	*	Adj. Factor	*	Total Area, ft^2	=	Electricity, kWh/month
ADMIN	E-Y-E	1.636		1.227		250,000		501,843
FH	E-Y-EHP	0.968		1.227		2,700		3,207
SHOP	F-N-F	0.397		1.227		50,000		24,356
TOTAL								529,406

Table 14
Building Nonelectric Use Adjustment

Bldg. Type	Group	Total Non-Elec. EUI	*	Adj. Factor	*	Area, ft^2	=	Nonelec. Total, kBtu/month (c)
ADMIN	E-Y-F	0.127		0.866		250,000		27,496
FH	E-Y-EHP	0		0.866		2,700		0
BRK	F-Y-F	2.797		0.866		25,000		60,555
TOTAL								88,051

Table 15
Ship Electric Use Adjustment

Ship Class/ Name	Connect Hours	*	Adj. Factor	*	Design Elec. Load, kW	=	Ship Electricity, kWh
CG-16	30		1.227		1,080		39,755
DD-931	10		1.227		1,150		14,111
CVN-68	40		1.227		5,990+5,760		576,690
TOTAL							630,556

Table 16
Ship Nonelectric Use Adjustment

Ship Class/ Name	Adj. Factor	*	Ship Steam Load	*	Connect Hours (same as Elec.)	=	Ship Steam Consumption, kBtu
CG-16	0.866		4.4		30		114
DD-931	0.866		2.7		10		23
CVN-68	0.866		20.1		40		696
TOTAL							834

3.3 Supplemental Reconciliation Process. In many cases, nonbuilding loads such as street lights or water and sewer energy are distributed among tenant organizations. Many installations have methods for assigning this energy use. If a method is ineffective or nonexistent, a supplemental reconciliation can be completed. This reconciliation is similar to the process described above but allocates the nonbuilding loads to the appropriate energy use components. The energy components may include metered and nonmetered buildings and/or ships.

This reconciliation is completed using the following steps:

a) Start with the initial final reconciliation completed above in Table 11 and remove from the table any nonbuilding loads that are to be apportioned to other tenants.

b) Recalculate the reconciliation. The difference should be equal to the sum of the values removed.

c) Create a new adjustment factor by dividing the difference by the sum of the energy use components to which the difference is to be apportioned.

d) Apply the new adjustment factor to the individual building estimates within the energy use components used to derive the adjustment factor (similar to Steps (h) and (i) above). This allocates the energy difference proportionally to each of the estimated values. The result of this process is building or ship consumption values that include a proportional amount of shared nonbuilding energy use. As a check of the process, the revised estimates should be re-inserted in the original reconciliation to ensure that the totals now match.

Section 4: WATER CONSUMPTION ESTIMATION AND RECONCILIATION

4.1 Data Collection. Potable water billing is based on unit cost and amount of water consumed. This includes interutility transfers, distribution losses, and general uses for common benefit operations. Regardless of whether water is purchased and/or produced at an activity, there is a cost associated with bringing it to consumers that must be considered when estimating billing. Billing estimates may be established for month, quarter, or annual periods to coincide with budgeting cycles. Shorter term estimates are sometimes needed for activities that have fluctuating requirements dictated by their tempo of operations. Since potable water costs fluctuate based on population, climatic conditions, and type of operation, estimates should be prepared as often as necessary to account for these variables.

a) Factors that affect water usage are listed below and should be considered in allocating billing:

(1) Peak demand

(2) Activity mission

(3) Climatic effects

b) If an activity is small or able to provide water at a low cost, billing estimates can be prepared for longer periods. At low usage levels, billing estimates are likely to show little fluctuation. Unpredicted operations and those that create a noncyclic impact on the tempo of operations often result in large water consumption fluctuations over short periods; therefore, billing estimates should be prepared more frequently. If a large installation uses more than 50 percent of a high cost water supply to support personnel, detailed billing estimates should be calculated to coincide with fluctuations in work shifts and number of people served. Similarly, when water is in short supply, billing estimates should take into account surcharges and consumption restrictions. In most cases, where unmetered water is furnished to tenants, evaluation of consumption is recommended. Evaluation of consumption is especially valuable if a function of a tenant changes or the number of people employed has substantially varied.

c) To develop billing estimates, water uses are grouped under four primary classifications:

(1) Domestic

(2) Commercial/industrial

(3) Ships (cold-iron support)

(4) Maintenance and losses

4.1.1 Domestic Use. Domestic water usage consists of the average daily water consumption expressed in gallons per person per day and includes water for drinking, baths, showers, toilets, and lawn irrigation. Per capita requirements for the following categories, listed in Table 17, should be used unless actual measurements or specific conditions dictate some other value.

a) Unaccompanied Personnel Housing: The average number of military and civilian personnel residing at the activity.

b) Family Housing: The average number of military and civilian personnel with dependents residing at the activity.

c) Workers: The average number of military and civilian personnel present for one shift (8 hours) per day.

d) Hospital Bed Population: The average number of bed patients residing in a hospital.

e) Transient Population: The average number of military and civilian personnel who register as visitors at the activity each day.

Table 17
Average Domestic Potable Water Requirements
Gallons Per Capita Per Day

Use Category	Desert		Temperate		Subtropical		Tropical
	Summer	Winter	Summer	Winter	Summer	Winter	All Seasons
Unaccompanied Personnel Housing	175	125	150	125	150	125	150
Family Housing	300	250	200	150	200	150	200
Workers (per shift)*	100	50	75	50	75	50	75
Hospital Bed Population	150	125	150	100	150	100	150
Transient Population	30	25	25	25	30	25	30

*One shift equals 8 hours.

4.1.2 Commercial/Industrial Use. These uses include, but are not limited to, cooling, processing, flushing, swimming pools, shops, laundries, dining facilities, air conditioning, and boiler makeup. Water requirements listed in Table 18 should be used unless actual measurements justify a revision. The following is a description of the various commercial and industrial uses:

a) Air Conditioning Usage: The average water usage is expressed in gallons per minute per ton for air conditioning units. Non-tower type air conditioning and refrigeration should be spot measured to estimate usage levels.

b) Machinery Cooling Usage: Water usage for machine cooling is expressed in gallons per minute of operation per brake horsepower and depends on the type of machinery. The usage for recirculating type air compressors is 3 gallons per horsepower hour.

c) Swimming Pools: Table gives daily water usage in gallons of make-up water (due to evaporation and leaks) to gallons of pool capacity. Maximum values should be used in desert type environments.

d) Vehicle Washing: Water usage for equipment washing is expressed in gallons for each piece of equipment washed during a day. These averages are based on equipment size and frequency of washing. Monthly usage, estimated in gallons, for Government and private cars, trucks, and buses are 50, 100, and 250 gallons, respectively. Other uses, such as automatic car washing facilities, should be determined based on experience and past consumption. If private car washing facilities are provided for privately-owned vehicles, determine the number of private cars owned by full population and adjust usage as necessary.

e) Irrigation and Lawn Sprinkling: The average monthly water usage is based on temperature, sunlight, rainfall, and soil type. Maximum values should be used in desert type environments. Units in Table 18 are gallons per acre day (gpad).

f) Other: Estimates for laundries (units are gallons of water per pound of clothes cleaned) and restaurants (units are in gallons per meal served) are given in Table 18.

Table 18
Commercial and Industrial Potable Water Requirements
Gallons Per Capita Per Day

Use	Unit	Minimum Requirement	Average Requirement	Maximum Requirement
Air conditioning:				
recirculating	gpm/ton	-	0.05	0.10
non-circulating	gpm/ton	-	2.50	4.00
Cooling - diesel engines:				
recirculating	gpm/bhp	-	0.01	0.02
non-circulating	gpm/bhp	0.25	0.33	0.40
Cooling - steam power plants, recirculating	gpm/bhp	1.30	0.80	1.70
Swimming pools:				
Indoor	gal/gal	0.006	0.04	0.10
Outdoor	gal/gal	0.04	0.15	0.25
Vehicle Washing:				
Cars	gal per vehicle washed	-	50	-
Trucks		-	100	-
Buses		-	250	-
Irrigation:				
Small lots	gpd/100 sq. ft.	16	24	32
Large areas	gpad	7,000	11,000	14,000
Laundries	gal/lb	3	4.5	6
Restaurants	gal/meal	0.5	2.0	4.0

4.1.3 Ships (Cold-Iron Support). Potable water consumption aboard ship varies according to climate, the number of personnel on board, and the class of ship. Ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm and CCB contains water consumption data for each class ship. If a particular ship is not listed in this table, then a similar ship (size, form, function) should be used as the best available data. Estimated water consumption is calculated by multiplying the number of days the ship received shore water by the ships potable water requirement listed in the ship's characteristics database (SHIPS) at http://www.efdlant.navfac.navy.mil/LANTOPS_15/home.htm.

4.1.4 Maintenance and Losses. The following factors significantly contribute to water consumption and are listed for informational purposes only. Due to the number of variables involved, an accurate estimation of water consumption due to losses cannot be made. Therefore, if metered values are not available, consumption due to these factors should be reconciled with the final billing statement (maintenance and distribution losses generally apply to all tenants at an activity). This process will be described in the next section.

a) Boiler Feedwater Usage: Boiler feedwater reflects the average daily water usage by each industrial boiler for makeup and other uses. When condensate return systems have been abandoned, the boiler is a “once through” system that requires more water to operate.

b) Street Cleaning: Street cleaning consists of the average monthly water usage for cleaning paved streets and parking lots. The average water usage for street cleaning is one-half gallon per square yard, although quantity of water will fluctuate based on pump pressure and size of nozzle. Street cleaning is commonly eliminated in areas where water is expensive or drought conditions exist.

c) Fire Hydrant Flushing: The average water discharge is generated from testing hydrant pressure and from clearing distribution lines of stagnant water. Fire hydrant flushing usage is expressed as an average of 1,200 gallons per minute (gpm) although it can range from 800 to 1,600 gpm depending on system pressure.

d) Firefighting and Training: Usage varies by incidents and training schedules.

e) System Losses: System losses are dependent on system age, maintenance practices, system design, and weather conditions. Unusual weather conditions may cause excessive losses.

4.2 Water Consumption Data Reconciliation. Reconciliation of all estimated and metered water consumption data with the total actual consumption is similar to the process performed for energy in Section 3.

NOTE
This process can be done manually or with any spreadsheet or database software. Using a spreadsheet or database is strongly recommended and will provide faster and easier calculation.

The process described here involves inputs of estimated and known water use. The calculation assistance presented earlier in this section can be used to prepare many of the inputs required. The forms and sample reconciliation displayed in Tables 19 through 23 were completed by following these steps:

a) Define a consumption period and group of buildings and/or other water uses (e.g., one-month time period and entire installation).

b) Collect and enter the total billing (usually utility metered) water consumption values for that time period in Table 19 as Billed Total. It is important to verify that these values relate directly to the group of buildings and other water uses under consideration as well as to the appropriate time period being considered.

c) Identify all metered and otherwise known water consumption quantities for buildings, ships, and other processes and enter in Table 19.

d) In the appropriate component spaces, enter estimated total consumption values for buildings, ships, maintenance, and losses that are not metered.

e) Sum the water component estimates and known consumption values to derive the Estimated Total. Compare these to the Billed Total consumption value entered in Step (b). If either of the summed totals do not match, an adjustment or correction is required.

Differences may be attributable to weather and operational factors that vary from installation to installation and are not always accurately represented by the estimation process. One large source of variance at many activities is water loss due to undetected leaks.

f) The final reconciliation step eliminates any remaining difference between the actual total consumption and the summed estimates and metered values. This difference is apportioned to water use components by a percentage Adjustment Factor calculated in Table 19. The Adjustment Factor is determined by dividing the Difference (Billed - Estimated) by the sum of selected Water Use Components to which the difference is to be apportioned (see equation in Table 19). For the example provided in Table 19, if the difference is to be apportioned among estimated (nonmetered) housing, ships, maintenance and losses, then the factor is one plus the difference (16.3) divided by the sum of all Estimated Domestic Water (6), Estimated Ship Water (1.7), and Maintenance Use and Losses (8.0) which is equal to 2.04.

g) The Adjustment Factor value calculated in Table 19 is then multiplied by each of the selected Water Use Components to derive new estimates. These new values are reinserted in the process (Table 20) and retotaled. At this point, the totals should match, and all values should be checked to ensure they are complete and reasonable.

The water components that are adjusted by Steps (f) and (g) should be those with the lowest level of confidence and, therefore, the greatest possible variance from actual use. In most cases, these will be the estimates for ships and losses.

h) The final step is the adjustment of the individual building and ship estimates within each water use component used to derive the adjustment factor. Tables 21 and 22 show a sample adjustment for buildings and ships. In each case, the adjustment factor is applied to each of the individual building groups or ship classes/names to proportionally distribute the difference calculated in Table 19. The new total values in Tables 21, 22, and 23 should match the adjusted component values in Table 21. Costs due to maintenance and losses are normally distributed among all tenant activities based on individual tenant water use.

Table 19
Total Water Reconciliation

Water Use Component	Million Gals/Month
Metered Domestic Water	3.15
Estimated Domestic Water	6
Metered Commercial/Industrial Water	3.45
Estimated Commercial/Industrial Water	2.25
Metered Ship Water	3.15
Estimated Ship Water	1.7
Maintenance Use and Losses	8
ESTIMATED TOTAL:	27.7
BILLED TOTAL:	44
Difference (Billed - Estimated):	16.3
Adjustment Factor (a):	2.04

(a) "Adjustment Factor" = [1+(Difference (billed - Estimated)/sum of selected Water Use Components)]. The selected Water Use Components are those water use areas to which the reconciliation difference is to be allocated. In this example, selected components are estimated domestic water, estimated ship water, maintenance and losses.

Table 20
Adjusted Total Water Reconciliation

Water Use Component	Million Gals/Month
Metered Domestic Water	3.15
Estimated Domestic Water	12.24
Metered Commercial/Industrial Water	3.45
Estimated Commercial/Industrial Water	2.25
Metered Ship Water	3.15
Estimated Ship Water	3.47
Maintenance Use and Losses	16.32
ESTIMATED TOTAL:	44
BILLED TOTAL:	44
Difference (Billed - Estimated):	0
Adjustment Factor:	1.0

Table 21
Domestic Water Use Adjustment

Bldg. Type	Original Estimate (MGAL)	*	Adj. Factor	=	New Estimate MGAL/Month
Enlisted Housing	3		2.04		6.12
Officer Housing	2		2.04		4.08
BEQ	0.6		2.04		1.22
BOQ	0.4		2.04		0.82
TOTAL					12.24

Table 22
Ship Water Use Adjustment

Ship Type	Original Estimate (MGAL)	*	Adj. Factor	=	New Estimate MGAL/Month
LPD-7	1.5		2.04		3.06
DD-931	0.2		2.04		0.41
TOTAL					3.47

Table 23
Maintenance and Loss Water Adjustment

Bldg. Type	Original Estimate (MGAL)	*	Adj. Factor	=	New Estimate MGAL/Month
Boiler Feedwater	2		2.04		4.08
Fire Hydrant Flushing	0.5		2.04		1.02
Leaks	5.5		2.04		11.22
TOTAL					16.32

APPENDIX A
BUILDING CATEGORY CODES AND BUILDING TYPES

This appendix contains the information used to assign building types based on the Navy five-digit building category code. A category code is assigned to each building listed in NAVFAC P-78 based on the building's function. Because many category codes describe the general function and operation of similar buildings, the category codes were grouped together and assigned to building types. These building types are used throughout this handbook to identify differences in operations, occupancy, or connected load. Table A-1 lists the building types and gives brief descriptions/examples of the kinds of buildings in the type. Table A-2 lists the category codes defined in FACSO RPT 11016/R8042R01, Facility Category Codes, and assigned to each building type.

Table A-1
Building Type Descriptions

Type	Description
ADMIN	Administration and office buildings
BRK	Bachelor enlisted and officer quarters
CHAPEL	Churches and chapels
CLINIC	Medical and dental clinics; no overnight stays
CLUB	Enlisted and officer clubs
DGR	Exchange facilities other than the commissary
DINING	Enlisted and officer dining halls, restaurants
ELEC	Electronics shops, communications, ADP, simulators, R&D electronics labs
FH	Family housing (all types)
GRO	Commissaries or other grocery stores
HANGAR	Aircraft hangars
HOSP	Hospital; medical care including overnight stays
HOTEL	Temporary quarters, guest houses
LAB	Medical, R&D (other than electronics), chemistry, environmental, etc.
LAUNDRY	Institutional/commercial laundries and dry cleaning plants
MWR	Morale, welfare, and recreation facilities
OTHER	Fuel dispensing buildings, detached restrooms, huts, kennels, typically unheated
PLANT	Heating and/or cooling plant buildings
PROCESS	Industrial buildings, production facilities, pump houses

APPENDIX A (Continued)

Table A-1 (Continued)
Building Type Descriptions

Type	Description
REC	Physical recreation, gyms, bowling alleys, indoor pools
SEC	Security, fire, police, and guard stations, brigs
STOR	Unheated and typically unoccupied storage
TRNG	Dependent schools, training classrooms, not simulators
WHS	Typically occupied and heated or cooled

Table A-2
Five-Digit Category Codes Assigned to Each Building Type

Bldg Type	Category Code
ADMIN	13740, 14130, 14140, 14141, 14142, 14181, 14315, 14320, 14325, 14328, 14335, 14341, 14365, 14380, 15511, 15620, 15964, 17160, 21370, 21825, 21930, 61010, 61040, 61070, 61071, 61072, 61073, 62010, 62020, 74017, 74021, 74029, 74033, 74037, 74088
BRK	14346, 14347, 72111, 72112, 72113, 72114, 72115, 72130, 72131, 72140, 72146, 72411, 72412, 72422, 72423, 72510, 72511
CHAPEL	73083 73084
CLINIC	22835, 54010, 55010, 73081
CLUB	74060, 74063, 74066, 74069, 74070
DGR	12315, 73042, 73085, 74001, 74002, 74003, 74005, 74007, 74009, 74018, 74019, 74031, 74034, 74035, 74036, 74038, 74071
DINING	72145, 72210, 72231, 72241, 72430, 73030, 74004, 74026, 74064, 74067
ELEC	13115, 13117, 13120, 13122, 13124, 13125, 13130, 13135, 13140, 13142, 13145, 13150, 13155, 13156, 13160, 13165, 13315, 13325, 13335, 13365, 13372, 13375, 13380, 13730, 13732, 13733, 14170, 14340, 15920, 17136, 21140, 21141, 21142, 21145, 21185, 21186, 21851, 61020, 74027, 74082
FH	71160, 71161, 71162, 71163, 71165, 71178, 71125, 71126, 71127, 71128, 71129, 71130, 71131, 71132, 71133, 71134, 71170, 71171, 71172, 71173, 71174, 71140, 71141, 71142, 71143, 71144, 71155, 71156, 71157, 71158, 71159, 71135, 71136, 71137, 71138, 71139, 71150, 71151, 71152, 71153, 71154, 71145, 71146, 71147, 71148, 71149, 71175, 71176, 71210, 71120, 71121, 71122, 71123, 71124, 71164
GRO	74008, 74023, 74083
HANGAR	14188, 21101, 21102, 21103, 21104, 21105, 21106, 21107, 21108, 21110, 21111, 21112, 21114, 21192, 21198

APPENDIX A (Continued)

Table A-2 (Continued)
Five-Digit Category Codes Assigned to Each Building Type

Bldg Type	Category Code
HOSP	51010, 51015
HOTEL	74020, 74022, 74081
LAB	14160, 14165, 14182, 14187, 14370, 14375, 21193, 21660, 31011, 31013, 31015, 31017, 31019, 31021, 31023, 31025, 31027, 31029, 31031, 31033, 31037, 31110, 31115, 31120, 31125, 31210, 31215, 31220, 31225, 31230, 31310, 31315, 31320, 31325, 31410, 31415, 31510, 31515, 31520, 31525, 31530, 31610, 31710, 31715, 31720, 31725, 31810, 31815, 31910, 31915, 31920, 31925, 31930, 31935, 31940, 32010, 32015, 32020, 32110, 53010, 53020, 53030, 53040, 53045, 53050
MWR	14330, 17125, 71432, 74012, 74025, 74039, 74056, 74074, 74075, 74076, 74080, 76010
OTHER	13720, 21368, 21605, 72320, 73036, 73065, 73066, 73070, 73075, 73076, 73080, 74089
REC	74028, 74040, 74042, 74043, 74045, 74046, 74050, 74052, 74053, 74054, 74055, 74079, 74084
SEC	14120, 14125, 73010, 73012, 73015, 73020, 73025, 87220
SHOP	21113, 21115, 21120, 21121, 21122, 21123, 21124, 21125, 21126, 21127, 21130, 21131, 21132, 21133, 21134, 21135, 21136, 21137, 21138, 21139, 21143, 21144, 21150, 21151, 21152, 21153, 21154, 21160, 21161, 21162, 21163, 21165, 21170, 21171, 21172, 21173, 21174, 21175, 21176, 21180, 21181, 21182, 21183, 21184, 21190, 21210, 21220, 21230, 21330, 21341, 21342, 21343, 21344, 21345, 21348, 21349, 21350, 21351, 21352, 21353, 21354, 21355, 21356, 21357, 21358, 21359, 21360, 21361, 21363, 21364, 21365, 21366, 21375, 21410, 21420, 21430, 21451, 21453, 21510, 21520, 21530, 21550, 21560, 21610, 21620, 21630, 21640, 21650, 21655, 21710, 21730, 21810, 21820, 21830, 21835, 21840, 21845, 21850, 21860, 21861, 21862, 21868, 21870, 21871, 21880, 21890, 21891, 21892, 21910, 22681, 22735, 44171, 74016, 74030
STOR	14219, 14310, 14311, 14345, 14355, 14360, 14377, 14378, 14986, 15521, 15610, 17177, 21164, 21195, 21196, 21199, 21277, 21362, 21377, 21440, 21677, 21777, 21865, 21877, 21920, 21925, 21977, 22977, 42112, 42122, 42132, 42135, 42142, 42148, 42152, 42162, 42172, 42410, 44112, 44130, 44135, 44140, 44170, 71410, 71430, 71431, 71477, 72340, 72360, 72377, 73077, 73082, 74077, 74087, 89077
TRNG	17110, 17115, 17117, 17120, 17135, 17140, 17145, 17150, 73045, 73050, 73055, 73060, 73084
WHS	43110, 44110, 44111, 44113, 44114, 44120, 44172, 44173, 51077, 61077, 62077, 72250, 73013, 74024, 74085, 74086

APPENDIX A (Continued)

Table A-3 lists three building types that are not included in the results presented in this handbook. The LAUNDRY building type is considered unique enough that it could not be combined with one of the other building types; further, sufficient data was not available to derive any EUI values. The PLANT building type represents buildings that contain equipment used to heat and/or cool other buildings. It is difficult to determine how much of the incoming energy is used in the building versus that which is transferred to other buildings. Also, it is assumed that most of these buildings (the ones that use substantial amounts of energy) are separately metered. The PROCESS building type represents a diverse collection of buildings ranging from pump houses to industrial factories. It is impossible to calculate energy consumption for these types of buildings without more detailed information. In these cases, other methods of calculating appropriate energy use values must be used.

Table A-3
Building Types and Category Codes Not Included in the EUI Tables

Bldg Type	Five-Digit Category Code
LAUNDRY	51020, 72330, 73040, 74013, 74015
PLANT	12520, 13110, 16130, 21197, 21367, 61030, 81109, 81159,
	81209, 81310, 82109, 82209, 82309, 82315, 82610, 82710,
	83109, 83114, 83139, 83141, 83229, 83309, 83320, 83340,
	84109, 84209, 84350, 84410, 84510, 86041, 89009, 89045
PROCESS	14210, 14321, 21187, 22110, 22120, 22130, 22210, 22220,
	22310, 22410, 22420, 22510, 22520, 22530, 22540, 22550,
	22560, 22610, 22615, 22620, 22625, 22630, 22635, 22640,
	22645, 22650, 22655, 22656, 22660, 22665, 22666, 22670,
	22675, 22680, 22685, 22686, 22688, 22710, 22720, 22730,
	22810, 22820, 22830, 22940, 22950, 22960, 22980, 73078

APPENDIX B
BUILDING ENERGY USE INTENSITIES AND SHIP LOADING FACTORS

Table B-1
Navy Building EUI Values and Weather Factors

Building Types (a)	Electric						Nonelectric	
			Cooling		Heating			Heating
	Misc. EUI (b) (kWh/ ft^2-mo)	DHW EUI (kWh/ ft^2-mo)	CDD(65) Factor [Wh/ft^2-CDD(65)]	WBH(73) Factor [Wh/ft^2-WBH(73)]	Resistance Factor (c) [Wh/ft^2-HDD(65)]	Heat Pump Factor (d) [Wh/ft^2-HDD(65)]	DHW EUI (kBtu/ ft^2-mo)	HDD(65) Factor [Btu/ft^2-HDD(65)]
ADMIN	0.804	0.246	2.93	0	1.87	0.748	1.117	8.51
BRK	0.407	0.598	3.00	0	1.06	0.423	2.725	4.81
CHAPEL	0.365	0.009	1.46	0	2.80	1.12	0.039	12.7
CLINIC	0.980	0.692	4.16	0	2.90	1.16	3.150	13.2
CLUB	0.967	0.593	4.65	0	1.06	0.426	2.700	4.84
DGR	1.133	0.218	4.84	0	1.12	0.447	0.992	5.09
DINING	2.050	0.593	1.99	0	1.06	0.426	2.700	4.84
ELEC	3.000	0.193	0.449	0	3.18	1.27	0.875	14.5
FH	0.487	0.318	0.539	1.74	1.94	0.777	1.450	8.83
GRO	2.742	0.239	6.31	0	1.13	0.451	1.092	5.13
HANGAR	0.808	0.134	3.10	0	1.94	0.777	0.609	8.83
HOSP	1.425	0.692	11.9	0	2.90	1.16	3.150	13.2
HOTEL	0.842	0.604	4.20	0	1.02	0.409	2.750	4.65
LAB	1.383	0.311	2.14	0	2.51	1.00	1.417	11.4
MWR	0.858	0.231	2.92	0	3.67	1.47	1.050	16.7
OTHER	0.638	0.458	3.54	0	3.03	1.21	2.083	13.8
REC	0.908	0.293	1.70	0	2.51	1.01	1.333	11.4
SEC	1.117	0.267	2.44	0	2.66	1.06	1.217	12.1
SHOP	0.397	0.134	1.59	0	1.94	0.777	0.609	8.83
STOR	0.118	0.064	1.52	0	1.84	0.737	0.290	8.38
TRNG	0.236	0.119	1.48	0	1.65	0.658	0.543	7.48
WHS	0.358	0.064	1.60	0	1.84	0.737	0.290	8.38
For SI unit use (m/ft, °C/°F, joule/Btu), multiply the values above by the appropriate conversion factor below:								
SI unit •	Misc. EUI (b) (kWh/ m^2-mo)	DHW EUI (kWh/ m^2-mo)	CDD(18) Factor [Wh/m^2-CDD(18)]	WBH•23C Factor [Wh/m^2-WBH(23)]	Resistance Factor (c) [Wh/m^2-HDD(18)]	Heat Pump Factor (d) [Wh/m^2-HDD(18)]	DHW EUI (kjoule / m^2-mo)	HDD(18) Factor [joule/m^2 - HDD(18)]
Factor •	10.76	10.76	19.38	10.76	19.38	19.38	11,356	20,441

APPENDIX B (Continued)

Table B-1 (Continued)
Navy Building EUI Values and Weather Factors

Notes:
-Data in this table is derived from analysis documented in Development of an Energy-Use Estimation Methodology for the Revised Navy Manual MO-303, E. E. Richman, J. M. Keller, A. G. Wood, and A. L. Dittmer. 1994PNL-10259, Pacific Northwest Laboratory, Richland, Washington.
(a) See Table A-1 for full names and descriptions of building types represented by the table data.
(b) Misc. electric EUI refers to lights, plug loads, and all other electric equipment not associated with heating, cooling, or DHW.
(c) Resistance refers to electric resistance heating: e.g., baseboard, forced air, radiant, reheat (if there is no main nonelectric heating coil).
(d) Heat pump refers to the heating energy from a heat pump only. Cooling from a heat pump is assumed to be the same as any other cooling equipment.

APPENDIX C
OUTDOOR LIGHTS

Table C-1
Outdoor Lighting Lamp and Ballast Wattage

Lamp Type	Lamp + Ballast Wattage (a)	Lamp Type	Lamp + Ballast Wattage (a)
High Pressure Sodium (HPS):		Low Pressure Sodium (LPS):	
HPS 35 W	43	LPS 18 W	30
HPS 50 W	64	LPS 35 W	65
HPS 70 W	94	LPS 55 W	82
HPS 100 W	130	LPS 90 W	135
HPS 150 W	185	LPS 135 W	173
HPS 200 W	240	LPS 180 W	225
HPS 215 W	270		
HPS 220 W	272	Metal Halide (MH):	
HPS 250 W	300	MH 32 W	42
HPS 310 W	365	MH 50 W	67
HPS 360 W	415	MH 70 W	95
HPS 400 W	465	MH 100 W	130
HPS 880 W	968	MH 150 W	188
HPS 940 W	1,034	MH 175 W	210
HPS 1000 W	1,100	MH 250 W	294
		MH 400 W	460
Incandescent: (b)		MH 750 W	830
Series		MH 1000 W	1,080
6.6 Amp:		MH 1500 W	1,610
11.2 Volt	75		
24 Volt	160	Mercury Vapor (MERC):	
34 Volt	225	MERC 50 W	72
50 Volt	330	MERC 75 W	100
20 Amp:		MERC 100 W	125
16.2 Volt	325	MERC 175 W	205
26.3 Volt	530	MERC 250 W	294
Multiple		MERC 400 W	454
INC 58 W	58	MERC 700 W	789
INC 92 W	92	MERC 1000 W	1,075
INC 103 W	103		
INC 189 W	189		

APPENDIX C (Continued)

Table C-1 (Continued)
Outdoor Lighting Lamp and Ballast Wattage

INC 202 W	202
INC 205 W	205
INC 295 W	295
INC 340 W	340
INC 405 W	405

(a) Data in this table is taken from Lighting Technology Screening Matrix (LTSM), J. A. Dirks, E. E. Richman, R. W. Schultz, and S.A. Shankle. 1992. Software Developed by Pacific Northwest Laboratory, Richland, Washington. Copyright 1992-1993 Battelle Memorial Institute.
(b) For other incandescent lamps, including quartz halogen, use the rated lamp wattage.

APPENDIX D[1]
TRANSMISSION LOSSES

Table D-1
Individual Transformer Losses by Size

No. of Phases	Voltage		Capacity (kVA)	Loss (W)	
	Primary	Secondary		No-Load	Load
1	2400/4160Y	120/240/277/480	5	34	103
1	2400/4160Y	120/240/277/480	10	68	136
1	2400/4160Y	120/240/277/480	15	84	198
1	2400/4160Y	120/240/277/480	25	118	304
1	2400/4160Y	120/240/277/480	37.5	166	404
1	2400/4160Y	120/240/277/480	50	185	535
1	2400/4160Y	120/240/277/480	75	285	700
1	2400/4160Y	120/240/277/480	100	355	920
1	2400/4160Y	120/240/277/480	167	500	1600
1	2400/4160Y	120/240/277/480	250	610	2780
1	2400/4160Y	120/240/277/480	333	840	3360
1	2400/4160Y	120/240/277/480	500	1140	4600
1	7200/12,470Y	120/240/277/480	5	41	103
1	7200/12,470Y	120/240/277/480	10	68	136
1	7200/12,470Y	120/240/277/480	15	84	198
1	7200/12,470Y	120/240/277/480	25	118	304
1	7200/12,470Y	120/240/277/480	37.5	166	404
1	7200/12,470Y	120/240/277/480	50	185	535
1	7200/12,470Y	120/240/277/480	75	285	700
1	7200/12,470Y	120/240/277/480	100	355	920
1	7200/12,470Y	120/240/277/480	167	500	1600
1	7200/12,470Y	120/240/277/480	250	610	2880
1	7200/12,470Y	120/240/277/480	333	840	3415
1	7200/12,470Y	120/240/277/480	500	1140	4500
1	13,200/22,860GndY	120/240/277/480	5	42	112
1	13,200/22,860GndY	120/240/277/480	10	73	142
1	13,200/22,860GndY	120/240/277/480	15	84	221
1	13,200/22,860GndY	120/240/277/480	25	118	319

[1]Although this table has value related to losses for older existing transformers, it is not accurate for transformers that the Navy has been procuring through NAVFAC guide specifications such as NFGS-16272. The no load losses derived from the NFGS are lower than those in this table. The load losses for larger transformers derived from the NFGS are lower than those in this table.

APPENDIX D[1] (Continued)

Table D-1 (Continued)
Individual Transformer Losses by Size

1	13,200/22,860GndY	120/240/277/480	37.5	166	419
1	13,200/22,860GndY	120/240/277/480	50	185	550
1	13,200/22,860GndY	120/240/277/480	75	285	765
1	13,200/22,860GndY	120/240/277/480	100	355	945
1	13,200/22,860GndY	120/240/277/480	167	500	1660
1	13,200/22,860GndY	120/240/277/480	250	610	2880
1	13,200/22,860GndY	120/240/277/480	333	840	3460
1	13,200/22,860GndY	120/240/277/480	500	1140	4500
1	13,800/23,900GndY	120/240/277/480	5	42	112
1	13,800/23,900GndY	120/240/277/480	10	73	142
1	13,800/23,900GndY	120/240/277/480	15	84	221
1	13,800/23,900GndY	120/240/277/480	25	118	319
1	13,800/23,900GndY	120/240/277/480	37.5	166	419
1	13,800/23,900GndY	120/240/277/480	50	185	550
1	13,800/23,900GndY	120/240/277/480	75	285	765
1	13,800/23,900GndY	120/240/277/480	100	355	945
1	13,800/23,900GndY	120/240/277/480	167	500	1660
1	13,800/23,900GndY	120/240/277/480	250	610	2880
1	13,800/23,900GndY	120/240/277/480	333	840	3460
1	13,800/23,900GndY	120/240/277/480	500	1140	4500
1	14,400/24,940GndY	120/240/277/480	5	42	112
1	14,400/24,940GndY	120/240/277/480	10	73	142
1	14,400/24,940GndY	120/240/277/480	15	84	221
1	14,400/24,940GndY	120/240/277/480	25	118	319
1	14,400/24,940GndY	120/240/277/480	37.5	166	419
1	14,400/24,940GndY	120/240/277/480	50	185	550
1	14,400/24,940GndY	120/240/277/480	75	285	765
1	14,400/24,940GndY	120/240/277/480	100	355	945
1	14,400/24,940GndY	120/240/277/480	167	500	1660
1	14,400/24,940GndY	120/240/277/480	250	610	2880
1	14,400/24,940GndY	120/240/277/480	333	840	3460
1	14,400/24,940GndY	120/240/277/480	500	1140	4500
3	4160GndY/2400X12,470GndY/7200	208Y/120	10	88	247
3	4160GndY/2400X12,470GndY/7200	208Y/120	15	106	280

[1] Although this table has value related to losses for older existing transformers, it is not accurate for transformers that the Navy has been procuring through NAVFAC guide specifications such as NFGS-16272. The no load losses derived from the NFGS are lower than those in this table. The load losses for larger transformers derived from the NFGS are lower than those in this table.

APPENDIX D[1] (Continued)

Table D-1 (Continued)
Individual Transformer Losses by Size

3	4160GndY/2400X12,470GndY/7200	208Y/120	25	149	430
3	4160GndY/2400X12,470GndY/7200	208Y/120	37.5	198	585
3	4160GndY/2400X12,470GndY/7200	208Y/120	45	223	683
3	4160GndY/2400X12,470GndY/7200	208Y/120	150	560	1690
3	4160GndY/2400X12,470GndY/7200	208Y/120	225	880	2420
3	4160GndY/2400X12,470GndY/7200	208Y/120	300	1050	3250
3	4160GndY/2400X12,470GndY/7200	208Y/120	500	1600	5200
3	4160GndY/2400X12,470GndY/7200	208Y/120	750	1800	8400
3	4160GndY/2400X12,470GndY/7200	208Y/120	1000	2100	10400
3	4160GndY/2400X12,470GndY/7200	208Y/120	1500	2900	16500
3	4160GndY/2400X12,470GndY/7200	480Y/277	75	360	990
3	4160GndY/2400X12,470GndY/7200	480Y/277	112	530	1270
3	4160GndY/2400X12,470GndY/7200	480Y/277	150	560	1690
3	4160GndY/2400X12,470GndY/7200	480Y/277	225	800	2500
3	4160GndY/2400X12,470GndY/7200	480Y/277	300	1050	3050
3	4160GndY/2400X12,470GndY/7200	480Y/277	500	1600	4900
3	4160GndY/2400X12,470GndY/7200	480Y/277	750	1800	7600
3	4160GndY/2400X12,470GndY/7200	480Y/277	1000	2100	8800
3	4160GndY/2400X12,470GndY/7200	480Y/277	1500	3300	13200
3	4160GndY/2400X12,470GndY/7200	480Y/277	2500	4800	21800
3	4160GndY/2400X12,470GndY/7200	480Y/277	3750	6500	29000
3	12,470GndY/7200	208Y/120	75	360	990
3	12,470GndY/7200	208Y/120	112	530	1270
3	12,470GndY/7200	208Y/120	150	560	1690
3	12,470GndY/7200	208Y/120	225	880	2420
3	12,470GndY/7200	208Y/120	300	1050	3250
3	12,470GndY/7200	208Y/120	500	1600	5200
3	12,470GndY/7200	208Y/120	750	1800	8400
3	12,470GndY/7200	208Y/120	1000	2100	10400
3	12,470GndY/7200	208Y/120	1500	2900	16500
3	12,470GndY/7200	480Y/277	75	360	990
3	12,470GndY/7200	480Y/277	112	530	1270
3	12,470GndY/7200	480Y/277	150	560	1690
3	12,470GndY/7200	480Y/277	225	880	2420

[1] Although this table has value related to losses for older existing transformers, it is not accurate for transformers that the Navy has been procuring through NAVFAC guide specifications such as NFGS-16272. The no load losses derived from the NFGS are lower than those in this table. The load losses for larger transformers derived from the NFGS are lower than those in this table.

APPENDIX D[1] (Continued)

Table D-1 (Continued)
Individual Transformer Losses by Size

3	12,470GndY/7200	480Y/277	300	1050	3250
3	12,470GndY/7200	480Y/277	500	1600	5200
3	12,470GndY/7200	480Y/277	750	1800	8400
3	12,470GndY/7200	480Y/277	3750	6500	29000
3	12,470 delta	2400/4160Y/2400	1000	2443	9037
3	12,470 delta	2400/4160Y/2400	1500	3455	12261
3	12,470 delta	2400/4160Y/2400	2500	4956	18237
3	12,470 delta	2400/4160Y/2400	3750	6775	26325
3	12,470 delta	2400/4160Y/2400	5000	8800	33325
3	24,940 delta	2400/4160Y/2400	1000	2533	9055
3	24,940 delta	2400/4160Y/2400	1500	3625	11588
3	24,940 delta	2400/4160Y/2400	2500	5338	17875
3	24,940 delta	2400/4160Y/2400	3750	7075	26625
3	24,940 delta	2400/4160Y/2400	5000	8725	34825
3	34,500	12,000	7500	11600	50600
3	69,000	4160	3750	6500	29000
3	69,000	12,000	2500	4800	21800
3	69,000	12,000	3750	6500	29000
3	69,000	12,000	7500	11600	50600
3	69,000	12,000	10000	15000	65000

[1] Although this table has value related to losses for older existing transformers, it is not accurate for transformers that the Navy has been procuring through NAVFAC guide specifications such as NFGS-16272. The no load losses derived from the NFGS are lower than those in this table. The load losses for larger transformers derived from the NFGS are lower than those in this table.

APPENDIX E
BLANK FORMS

Notes:
(a) Fuel type abbreviations are as follows:
E = electric
ER = electric resistance heat (e.g., baseboard, forced air, radiant)
EHP = electric heat pump heat
FNG = fossil fuel - natural gas
FFO = fossil fuel - fuel oil
FS = fossil fuel – steam
FO = other fossil fuel (e.g., propane, hot water, coal, wood)
NH = no heat
(b) Group is a code used to group similar buildings by the dhw fuel type, presence/absence of cooling, and heating fuel type. This field is simply the previous three fields combined.

Figure E-1
Facility Data From Real Property Data Sources

APPENDIX E (Continued)

Bldg. Type	Bldg. No.	Area, ft^2	Electricity, kWh/month or year
TOTAL			

Figure E-2
Metered Building Electric Data

APPENDIX E (Continued)

Bldg. Type	Group	Misc. EUI	+	DHW EUI (a)	+	[CDD Factor (b)]	*	[CDD/ 1000]	+	[WBH Factor (c)]	*	[WBH /1000]	+	[Elec. Heat Factor (d)]	*	[HDD /1000]	=	Total Elec. EUI	*	Total Area, ft^2	=	Electricity kWh/mo (e)
TOTAL																						

Notes:
(a) See first term in Group. If it is an E, then enter the electric DHW EUI from EUI Table; otherwise, enter zero.
(b) See second term in Group. If it is a Y, enter the CDD factor from the EUI Table; otherwise, enter zero.
(c) If the building type is FH, enter the WBH factor from the EUI table; otherwise, enter zero.
(d) See the third term in Group. If it is ER, enter the electric resistance factor; if it is EHP, enter the heat pump factor. Otherwise enter zero.
(e) If the calculation is being done on an annual basis, the Misc. and DHW EUI must be multiplied by 12.

Figure E-3
Estimated Building Electric Data

APPENDIX E (Continued)

Bldg. Type	Bldg. No.	Area, ft^2	Fossil Fuels, kBtu/month or year
TOTAL			

Figure E-4
Metered Building Nonelectric Data

APPENDIX E (Continued)

Bldg. Type	Group	DHW EUI (a)	+	[HDD Factor (c)]	*	[HDD /1000]	=	Total Non-Elec. EUI	*	Area, ft^2	=	Nonelectric Total, kBtu/month (c)
TOTAL												

Notes:
(a) If the first letter in the first term in Group is F, enter the nonelectric DHW EUI for the building type from the EUI table; otherwise, enter zero.
(b) If the first letter of the third term in Group is F, enter the nonelectric HDD modifier for the building type from the EUI table; otherwise, enter zero.
(c) If the calculation is being done on an annual basis, the DHW EUI must be multiplied by 12.

Figure E-5
Estimated Building Nonelectric Data

APPENDIX E (Continued)

Ship Class/ Name	Connect Hours	*	Design Elec. Load, kW	=	Ship Electricity, kWh
TOTAL					

Figure E-6
Metered and Estimated Ship Electric Data

APPENDIX E (Continued)

Ship Class/ Name	Intermittent Steam, kBtu/h	+	Constant Steam, kBtu/h	=	Ship Steam Load	*	Connect Hours	=	Ship Steam Consumption, kBtu
TOTAL									

Figure E-7
Metered and Estimated Ship Nonelectric Data

APPENDIX E (Continued)

Energy Use Component	Electricity, kWh	Natural Gas, kBtu	Fuel Oil, kBtu	(b)
Metered Building Energy				
Estimated Building Energy				
Metered Ship Energy				
Estimated Ship Energy				
-				
-				
Elec. Trans. & Dist. Losses				
Central Plant Efficiency & Dist. Losses				
Street and Exterior Lights				
Process Energy				
Water and Sewer Energy				
Exterior Communications				
Energy Transfers to Off-Site				
Misc. Other Energy Use (not assoc. with above)				
-				
-				
ESTIMATED TOTAL:				
BILLED TOTAL:				
Difference (Billed - Estimated):				
Adjustment Factor (a):				

(a) "Adjustment Factor" = [1+(Difference (billed - Estimated)/sum of selected Energy Use Components)]. The selected Energy Use Components are those energy use areas to which the reconciliation difference is to be allocated.

(b) Data for other fuel types may be entered in additional columns.

Figure E-8
Total Energy Reconciliation

APPENDIX E (Continued)

Energy Use Component	Electricity, kWh	Natural Gas, kBtu	Fuel Oil, kBtu	(b)
Metered Building Energy				
Estimated Building Energy				
Metered Ship Energy				
Estimated Ship Energy				
-				
-				
Elec. Trans. & Dist. Losses				
Central Plant Efficiency & Dist. Losses				
Street and Exterior Lights				
Process Energy				
Water and Sewer Energy				
Exterior Communications				
Energy Transfers to Off-Site				
Misc. Other Energy Use (not assoc. with above)				
-				
-				
ESTIMATED TOTAL:				
BILLED TOTAL:				
Difference (Billed - Estimated):				
Adjustment Factor (a):				

Figure E-9
Adjusted Total Energy Reconciliation

APPENDIX E (Continued)

Bldg. Type	Group	Total Electric EUI	*	Adj. Factor	*	Total Area, ft^2	=	Electricity kWh/mo
TOTAL								

Figure E-10
Building Electricity Use Adjustment

APPENDIX E (Continued)

Bldg. Type	Group	Total Non-Elec. EUI	*	Adj. Factor	*	Area, ft^2	=	Nonelectric Total, kBtu/month (c)
TOTAL								

Figure E-11
Building Nonelectric Use Adjustment

APPENDIX E (Continued)

Ship Class/ Name	Connect Hours	*	Adj. Factor	*	Design Elec. Load, kW	=	Ship Electricity, kWh
TOTAL							

Figure E-12
Ship Electric Use Adjustment

APPENDIX E (Continued)

Ship Class/ Name	Adj. Factor	*	Ship Steam Load	*	Connect Hours (same as Elec.)	=	Ship Steam Consumption, kBtu
TOTAL							

Figure E-13
Ship Nonelectric Use Adjustment

APPENDIX E (Continued)

Lamp Type	Count	*	Lamp + Ballast Wattage	*	Hours	/	1000 (W/kW)	=	Street lighting Energy, kWh
TOTAL									

Figure E-14
Exterior Lighting Energy

APPENDIX E (Continued)

Season/Month/...	Peak Load (MW)	Average Load (MW)	Total Nameplate Capacity (kVA)	Demand Loss Factor (F_{DLS})	Load Factor (F_{LD})	Energy Loss Factor (F_{ELS})

Figure E-15
Electrical Transformer Loss Factors

APPENDIX E (Continued)

No. of Phases	Voltage (Prim/Sec)	Capacity (kVA)	No. of Units	No Load Loss (W)	Load Loss (W)	Energy Loss (kWh/mo)	Demand Loss (W)
TOTAL							

Figure E-16
Electrical Transformer Losses

APPENDIX E (Continued)

Bldg. Type	Bldg. No.	MGAL/Month
TOTAL		

Figure E-17
Metered Building Water Data

APPENDIX E (Continued)

Ship Type	Ship Hull No.	MGAL/Month
TOTAL		

Figure E-18
Metered Ship Water Data

APPENDIX E (Continued)

Bldg. Type	Bldg. No.	MGAL/Month
TOTAL		

Figure E-19
Estimated Building Water Data

APPENDIX E (Continued)

Ship Type	Ship Hull No.	MGAL/Month
TOTAL		

Figure E-20
Estimated Ship Water Data

APPENDIX E (Continued)

Water Use Component	MGAL/Month
Metered Domestic Water Estimated Domestic Water Metered Commercial/Industrial Water Estimated Commercial/Industrial Water Metered Ship Water Estimated Ship Water	
Maintenance Use and Losses	
ESTIMATED TOTAL:	
BILLED TOTAL:	
Difference (Billed - Estimated):	
Adjustment Factor (a):	
(a) "Adjustment Factor" = [1+(Difference (billed - Estimated)/sum of selected Water Use Components)]. The selected Water Use Components are those water use areas to which the reconciliation difference is to be allocated. In this example, selected components are estimated domestic water, estimated ship water, maintenance and losses.	

Figure E-21
Total Water Reconciliation

APPENDIX E (Continued)

Water Use Component	MGAL/Month
Metered Domestic Water Estimated Domestic Water Metered Commercial/Industrial Water Estimated Commercial/Industrial Water Metered Ship Water Estimated Ship Water	
Maintenance Use and Losses	
ESTIMATED TOTAL: BILLED TOTAL:	
Difference (Billed - Estimated): Adjustment Factor:	

Figure E-22
Adjusted Total Water Reconciliation

Bldg. Type	Original Estimate (MGAL)	*	Adj. Factor	=	New Estimate MGAL/Month
TOTAL					

Figure E-23
Domestic Water Use Adjustment

APPENDIX E (Continued)

Ship Type	Original Estimate (MGAL)	*	Adj. Factor	=	New Estimate MGAL/Month
TOTAL					

Figure E-24
Ship Water Use Adjustment

Bldg. Type	Original Estimate (MGAL)	*	Adj. Factor	=	New Estimate MGAL/Month
TOTAL					

Figure E-25
Maintenance and Loss Water Adjustment

REFERENCES

NOTE: THE FOLLOWING REFERENCED DOCUMENTS FORM A PART OF THIS HANDBOOK TO THE EXTENT SPECIFIED HEREIN. USERS OF THIS HANDBOOK SHOULD REFER TO THE LATEST REVISIONS OF CITED DOCUMENTS UNLESS OTHERWISE DIRECTED.

<u>FEDERAL/MILITARY SPECIFICATIONS, STANDARDS, BULLETINS, HANDBOOKS, AND NAVFAC GUIDE SPECIFICATIONS</u>:

Unless otherwise indicated, copies are available from the Naval Publishing and Printing Service Office (NPPSO), Standardization Document Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

P-PUBLICATIONS

NAVFAC P-78	Navy Facilities Assets Data Base Management System Procedures Manual
NAVFAC P-89	Engineering Weather Data for Design and Construction

HANDBOOKS

MIL-HDBK-1025/2	Dockside Utilities for Ship Service

GUIDE SPECIFICATIONS

NFGS-16272	Three Phase Pad-Mounted Transformers

<u>OTHER GOVERNMENT DOCUMENTS AND PUBLICATIONS</u>:

FACSO Rpt 11016/R4640R01	Navy Real Property - Class 1 and 2: Detail
FACSO Rpt 11016/R8042R01	Facility Category Codes
OPNAVINST 4100.5	Energy Management

(Unless otherwise indicated, copies are available from Standardization Document Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

NON-GOVERNMENT PUBLICATIONS:

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	Motors and Generators.

(Unless otherwise indicated, copies are available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209.)

Dirks, J. A., E. E. Richman, R. W. Schultz, and S. A. Shankle	Lighting Technology Screening Matrix (LTSM)
Dixon, D. R., P. R. Armstrong, and J. M. Keller	Griffis Air Force Base Integrated Resource Assessment, Volume 2: Baseline Detail
Halverson, M. A., E. E. Richman, J. E. Dagle, B. J. Hickman, K. K. Daellenbach, and G. P. Sullivan	Vandenberg Air Force Base Integrated Resource Assessment, Volume 2: Baseline Detail
Keller, J. M, G. P. Sullivan, R. R. Wahlstrom, and L. L. Larson	Robins Air Force Base Integrated Resource Assessment, Volume 2: Baseline Detail
Richman, E .E., J. M. Keller, A. L. Dittmer, and D. L. Hadley	Fort Irwin Integrated Resource Assessment, Volume 2: Baseline Detail
Richman, E. E., J. M. Keller, A. G. Wood, and A. L. Dittmer	Development of an Energy-Use Estimation Methodology for Revised Navy Manual MO-303

(Unless otherwise indicated, copies are available from Pacific Northwest Laboratory, Richland, WA)

Earley, M. W., R. H. Murray, and J. M. Caloggero	The National Electrical Code Handbook: Based on the 1999 Edition of the National Electrical Code

(Unless otherwise indicated, copies are available from the National Fire Protection Association (NFPA), One Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.)

Gonen, T. — Electric Power Distribution System Engineering

(Unless otherwise indicated, copies are available from McGraw-Hill Book Company, New York, NY.)

Nadel, S., M. Shepard, S. Greenberg, G. Katz, and A. T. de Almeida — Energy Efficient Motor Systems: A Handbook on Technology, Program, and Policy Opportunities

(Unless otherwise indicated, copies are available from American Council for an Energy-Efficient Economy, Washington, DC.)

GLOSSARY

ASHRAE. American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc.

Btu. British thermal unit.

CCB. Construction Criteria Base.

DHW. Domestic hot water.

EUI. Energy use intensities.

gpad. Gallons per acre day.

HID. High intensity discharge.

NAVFAC. Naval Facilities Engineering Command.

PWC/Ds. Public Works Centers and Departments.

CUSTODIAN:
NAVY – YD2

PREPARING ACTIVITY:
NAVY – YD2

PROJECT NO.
FACR-5018

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7, and send to preparing activity.

3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-HDBK-1133	2. DOCUMENT DATE *(YYMMDD)* 990930

3. DOCUMENT TITLE : ESTIMATING ENERGY AND WATER CONSUMPTION FOR SHORE FACILITIES AND COLD IRON SUPPORT FOR SHIPS

4. NATURE OF CHANGE (identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) DSN *(If applicable)*	7. DATE SUBMITTED: *(YYMMDD)*

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE *(Include Area Code)*
COMMANDING OFFICER NAVAL FACILITIES ENGINEERING SERVICE CENTER	(1) Commercial (2) DSN
c. ADDRESS *(Include Zip Code)* 1100 23RD AVENUE PORT HUENEME, CA 93043-4370	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533 Fort Belvoir, Virginia 22060-6221 Telephone (703) 767-6888 DSN 427-6888