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**HAWAII DEMAND-SIDE MANAGEMENT
RESOURCE ASSESSMENT**

FINAL REPORT
REFERENCE VOLUME 1

BUILDING PROTOTYPE ANALYSIS

Prepared for:

The Department of Business,
Economic Development, and Tourism
State of Hawaii

April 1995

Prepared by:

NEOS Corporation
8950 Cal Center Drive, Suite 255
Sacramento, California 95826
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RESOURCE ASSESSMENT**

FINAL REPORT

REFERENCE VOLUME 1

BUILDING PROTOTYPE ANALYSIS

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- College
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1.0 INTRODUCTION

This report provides a detailed description of, and the baseline assumptions and simulation results for, the building prototype simulations conducted for the building types designated in the Work Plan for Demand-side Management Assessment of Hawaii's Demand-Side Resources (HES-4, Phase II). This report represents the second revision to the initial building prototype description report provided to DBEDT early in the project. Modifications and revisions to the prototypes, based on further calibration efforts and on comments received from DBEDT Staff have been incorporated into this final version. These baseline prototypes form the basis upon which the DSM measure impact estimates and the DSM measure data base were developed for this project.

On-site survey results and the Hawaii Model Energy Code were the prime sources of information for development of the building prototypes. The Hawaii Model Energy Code was primarily influenced by the ASHRAE Standard 90.1-1989, by ASHRAE 90.2P, California's Title 24, and by USDOE Standard for nonresidential buildings. In addition, the Code encompasses the specifics for the Islands especially regarding natural ventilation. The July 1993 version of the Code is the version that is referred to in this text when delimiting New and Existing building types. The Model Energy Code impact analysis, which utilized the DOE-2 building simulation model, was an important source of information for the New vintage prototype analysis. The City and County of Honolulu adopted the Model Energy Code on October 27, 1994; the County of Hawaii on November 23, 1994. Both counties exempted low-rise residential buildings. Maui and Kauai Counties will consider code adoption in the spring of 1995.

This report presents detailed information for each of the 17 different building prototypes developed for use with the DOE-21E program (23 buildings in total, including resorts and hotels defined separately for each island) to estimate the impact of the building technologies and measures included in this project.

The remainder of this section presents some nomenclature and terminology utilized in the reports, tables, and data bases developed from this project to denote building type and vintage. Section 2 contains a more detailed discussion of the data sources, the definition of the residential sector building prototypes, and results of the DOE-2 analysis. Section 3 provides a similar discussion for the commercial sector. The prototype and baseline simulation results are presented in a separate section for each building type. Where possible, comparison of the baseline simulation results with benchmark data from the ENERGY 2020 model or other demand forecasting models specific to Hawaii is included for each building. Appendix A contains a detailed listing of the commercial sector baseline indoor lighting technologies included in the existing and new prototypes by building type.

Building types are referred to using the keywords shown below.

Keyword	Building Type
SFAM	Single-Family Home
MFAM	Multi-Family Unit
SOFF	Small Office
LOFF	Large Office
SRET	Small Retail
LRET	Large Retail
SDRE	Sit-Down Restaurant
FFRE	Fast Food Restaurant
GROC	Grocery Store
RWAR	Refrigerated Warehouse
NRWA	Non-Refrigerated Warehouse
HOSP	Hospital
SCHL	School
COLL	College
*HOT	Hotel - Four Locations - Hawaii, Kauai, Maui, and Oahu
*RST	Resort - Four Locations - Hawaii, Kauai, Maui, and Oahu
APTM	Master-Metered Apartment

Prototypes are developed for the four counties: Kauai, Hawaii, Maui, and Honolulu. However, for Office (large and small), Retail (large and small), Restaurant (sit-down and fast food), Grocery, School, College, Hospital, Warehouse (refrigerated and non-refrigerated), and Master-Metered Apartment, prototypes are developed for Honolulu County only (since their concentrations are significant for Honolulu County only). Building prototypes for Hotel and Resort are developed for all four counties and vary by weather patterns and directional orientation unique to the counties.

The following keywords are used to denote vintage:

Keyword	Vintage
EXISTING	Construction (or appliance purchase) prior to Hawaii Model Energy Code
NEW	Construction (or appliance purchase) after Hawaii Model Energy Code

The following four counties, Hawaii, Kauai, Maui, and Honolulu, are the primary focus for both residential and commercial prototypes.

Keyword	Islands within the Counties (Relevant Utility)
HAWAII	Hawaii (HELCO)
KAUAI	Kauai (Kauai Electric)
MAUI	Lanai, Maui, and Molokai (MECO)
HONOLULU	Oahu (HECO)

2.0 RESIDENTIAL BUILDING PROTOTYPES

Two residential building types are defined for the analyses relevant to the technologies and measures appropriate to this sector. These are the single-family residence and the multi-family unit. This section presents an overview of the data sources examined and assumptions made for the development of the residential DOE-2.1E prototypes utilized for the baseline and parametric analyses and the baseline Unit Energy Consumption (UEC) values from the DOE-2.1E analysis.

2.1 Residential Sector Data Sources and Assumptions

As noted above, the residential prototypes utilized for this project are derived from a number of different sources. These sources include: (1) prototypes developed by NEOS (1994) under contract with Southern California Edison (SCE), representing the California Conservation Inventory Group (CCIG); (2) saturation information from Residential Customer Surveys performed for HELCO, HECO, and MECO; (3) 1990 census data; (4) the Home Energy Survey performed by DBEDT (1992); (5) the Hawaii Model Energy Code (DBEDT, 1993); (6) an impact analysis of the Hawaii Model Energy Code performed by Eley Associates (1993); and (7) comments received from DBEDT staff on a preliminary draft of this document. Single- and multi-family prototypes were developed for two vintages (EXISTING and NEW). The two vintages correspond to those residences built before the Hawaii Model Energy Code (DBEDT, 1993) was conceived and implemented (EXISTING) and those built after (NEW). Analyses were conducted by NEOS staff to derive average characteristics for construction, building equipment, occupancy, and building operation for each vintage.

2.2 Residential Building Types

The prototype for each of the single-family and multi-family building types is described in detail in the following sections. The physical characteristics and geometry of each building are defined, as well as the building equipment. Figures are included which depict the baseline and target UEC values by end-use resulting from the simulations.

2.2.1 Single-Family Residence

Building I.D.: "SFAM"

Building Description: "Single-Family Residence"

As noted above, the single-family prototype is developed from information from NEOS (1994), Eley Associates (1993) and the various Hawaii surveys described above.

In all cases, the single-family prototype is represented by a building with an equal amount of wall, window, door, and roof area facing each cardinal orientation as depicted below. The prototypes, therefore, represent an average of building population in which homes are constructed facing every direction.

SINGLE FAMILY HOUSE: perspective

The floor area, window area, roof area, wall area, and the number of occupants per home are specified to vary by vintage. These values are shown below.

BASE CASE PROTOTYPE SPECIFICATIONS SINGLE FAMILY

Vintage		Vintage	
Existing	New	Existing	New
Total Floor Area		Window Area	
1005	1300	201	299
Roof Area		Wall Area	
727	940	914	1359

The number of occupants in the single-family prototype is 3.0 for the EXISTING vintage and 3.2 for the NEW vintage. The single-family prototype is simulated with an electric/central air-conditioning unit, an electric/room air-conditioning unit and with no cooling. The building is modeled as a single zone with

thermostat set points of 74° F for cooling for weekends and weekday evenings and essentially turned off during working hours. The air-conditioner compressor is assumed to be a single-speed compressor unit.

Since water heating has the greatest potential for energy savings through DSM for the Residential sector, it is important to characterize its nature before and after implementation of the Hawaii Model Energy Code. For both the EXISTING and NEW vintages an electric resistance water heater and a gas water heater are modeled in the prototypes. Solar water heaters (with electric or gas back-up) and heat pump water heaters are simulated as DSM measures. The standard water heater size in the single-family prototype is assumed to be 40 gallons. Efficiency and loss characteristics for the electric and gas water heaters by vintage are shown below.

DOMESTIC WATER HEATER SPECIFICATIONS SINGLE FAMILY

Electric Water Heater		Gas Water Heater	
Existing	New	Existing	New
Recovery Efficiency		Recovery Efficiency	
97%	99%	72%	76%
Loss Factor		Loss Factor	
2%	1%	4.5%	4%

The cooling capacities and cooling efficiencies by vintage for the single family, electric, base case prototype are shown in the following table.

COOLING CHARACTERISTICS SINGLE FAMILY

Vintage	
Existing	New
Cooling Capacity (tons)	
2.5	3.0
Cooling EER	
8.0	9.7

Roof insulation (R-Value) for the baseline prototypes are summarized in the following table. Roof construction is composed of shingles, permeable felt, plywood on wood frame (10% framing factor), and gypsum plaster.

**ROOF INSULATION VALUES
SINGLE-FAMILY**

Roof Insulation Values	
Existing	New
0.0	11.0

Exterior walls are assumed to be composed of plywood or fiberboard panels on wood frame construction (15% framing factor) and gypsum board. The cavity and sheathing insulation values are shown below. Note, wall insulation is required by the Model Energy Code only in residences that are air conditioned and only in walls that are unshaded. The residential portion of the code has not yet been adopted.

**WALL INSULATION VALUES (CAVITY AND SHEATH)
SINGLE FAMILY**

Wall Insulation (Cavity)		Wall Insulation (Sheath)	
Existing	New	Existing	New
0.0	11.0	0.0	0.0

Both the EXISTING and NEW vintages are slab-on-grade. Window height is fixed at 4.5 feet, while the width is determined as a function of floor area and glazing percentage. Windows are modeled with 2 foot overhangs at a height of 1 foot above the top of each window. Window maintenance (i.e. opening and closing shades) is utilized. Glass areas (as a % of floor area) and glazing U-values (including frame) are shown below.

**GLASS AREA AND GLASS U-VALUE
SINGLE FAMILY**

Glass Area (% of floor)		Glass U-Value	
Existing	New	Existing	New
20	23	1.31	1.31

The residence is assumed to be surrounded by a limited amount of shading that represents a generic combination of adjacent buildings and nearby trees. Other shading-related inputs, such as terrain and shielding factors correspond to a suburban setting with low buildings.

The Hawaii Model Energy Code is written such that there exists a maximum allowable Relative Solar Heat Gain (RSHG) based upon the window to wall ratio (WWR) of the structure. Since the WWR for our single family prototype is .22, the maximum allowable RSHG is .90 for north facing walls and .70 for east, west, and south facing walls. The RSHG is a linear function of the shading coefficient of glass on the relevant wall, the shading coefficient of exterior shade screens, the shading coefficient of the interior

screens, and the overhang projection factor. A combination of these factors are incorporated into the NEW vintage single-family prototype to yield the appropriate RSHG value.

The following table presents a summary of the annual energy use for the various single-family models. The target energy use values are from ENERGY 2020 and HECO's REEPS Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). CAC refers to central air-conditioning, RAC refers to room air-conditioning and None in the first column refers to a building model with no air-conditioning. There are no target values for room air-conditioning nor exterior lighting energy use. It should be noted that target values were only available for new and existing homes combined. The DSM parametric analysis, on the other hand, requires UEC values specific to new and existing homes.

These data are also presented in the two graphs that follow.

**Summary of Annual Energy Use by Vintage, Fuel Type and Cooling Type
Single-Family**

	End Use Categories					
	Cooling	DHW	Other-kWh	Other-gas	In-LIGHTS	Ex-LIGHTS
	kWh	kWh or therm	kWh	therms	kWh	kWh
New Vintage Electric House						
Target UECs	4431	3154	6471	0	593	na
Central A/C	4301	2826	6174	0	1100	425
Room A/C	1906	2826	6174	0	1100	425
No A/C		2826	6174	0	1100	425
New Vintage Gas Building						
Target UECs	4431	170	4907	79	593	na
Central A/C	4253	200	4950	79	1100	425
Room A/C	1859	200	4950	79	1100	425
No A/C		200	4950	79	1100	425
Existing Vintage Electric House						
Target UECs	4431	3154	7588	0	593	na
Central A/C	5422	3769	7268	0	1100	425
Room A/C	2161	3769	7268	0	1100	425
No A/C		3769	7268	0	1100	425
Existing Vintage Gas Building						
Target UECs	4431	170	5886	85	593	na
Central A/C	5727	247	5948	84	1100	425
Room A/C	2143	247	5948	84	1100	425
No A/C		247	5948	84	1100	425

**Annual Energy Use for Single-Family Electric House
New and Existing Vintages**

**Annual Energy Use for Single-Family Gas House
New and Existing Vintages**

2.2.2 Multi-Family Residence

Building I.D.: "MFAM"

Building Description: "Multi-Family Residence"

The multi-family prototype is a composite derived from NEOS (1994) prototypes for the CCIG project, information from various residential surveys of the Islands, and a survey of Hawaiian building departments (Eley Associates, 1993).

In all cases, the multi-family prototype is represented by a unit with an equal amount of wall, window, door, and roof area facing each cardinal orientation as depicted below. The physical dimensions and attributes of the multi-family prototype are derived from averaging various unit types (end units and interior units) together. The prototypes, therefore, represent an average of building population in which multi-family units are constructed facing every direction.

MULTI-FAMILY UNIT: perspective

The floor area, window area, roof area, and wall area per home vary by vintage. These values are shown below.

BASE CASE PROTOTYPE SPECIFICATIONS MULTI-FAMILY

Vintage		Vintage	
Existing	New	Existing	New
Total Floor Area		Window Area	
1003	1090	70	65
Roof Area		Wall Area	
602	621	698	652

The number of occupants in both vintages, NEW and EXISTING, was specified as 2.0. The multi-family prototype is simulated with an electric window unit as well as with central air-conditioning and with no air-conditioning. The building is modeled as a single zone with thermostat set points of 74° F for cooling for weekends and weekday evenings and turned off during working hours. The air-conditioner compressor is assumed to be a single-speed compressor unit.

Since water heating has the greatest potential for energy savings through DSM for the Residential sector, it is important to characterize its nature before and after implementation of the Hawaii Model Energy Code. For both the EXISTING and NEW vintages an electric resistance water heater and a gas water heater are modeled in the prototypes. Heat pump water heaters are simulated as a DSM measure. The standard water heater size in the multi-family prototype is assumed to be 30 gallons. Efficiency and loss characteristics for the electric and gas water heaters by vintage are shown below.

DOMESTIC WATER HEATER SPECIFICATIONS MULTI-FAMILY

Electric Water Heater		Gas Water Heater	
Existing	New	Existing	New
Recovery Efficiency		Recovery Efficiency	
97%	99%	72%	76%
Loss Factor		Loss Factor	
2.4%	1.2%	5.4%	4.5%

The cooling capacities and cooling efficiencies by vintage for the multi-family, electric, base case prototype are shown in the table below.

COOLING CHARACTERISTICS MULTI-FAMILY

Vintage	
Existing	New
Cooling Capacity (tons)	
2.5	2.75
Cooling EER	
8.5	10.0

Roof insulation (R-value) for the baseline prototypes are summarized in the table below. Roof construction is composed of shingles, permeable felt, plywood on wood frame (10% framing factor), insulation, and gypsum plaster.

**ROOF INSULATION VALUES
MULTI-FAMILY**

Roof R-Value	
Existing	New
0.0	11.0

Exterior walls are assumed to be composed of plywood or fiberboard panels on wood frame construction (15% framing factor) and gypsum board. The cavity and sheathing insulation values are shown below. Again, low rise residential buildings (both single-family and multi-family) are required to have wall insulation, when air conditioned, in the unshaded walls.

**WALL INSULATION (CAVITY AND SHEATH) BY VINTAGE
MULTI-FAMILY**

Wall Insulation (Cavity)		Wall Insulation (Sheath)	
EXISTING	NEW	EXISTING	NEW
0.0	13.0	0.0	0.0

The EXISTING and NEW vintages are slab-on-grade. Total glazing area also varies by vintage, and is equally divided among the four exterior walls. Window height is fixed at 4.5 feet, while the width is determined as a function of floor area and glazing percentage. Windows are modeled with 2 foot overhangs at a height of 1 foot above the top of each window. Window maintenance (i.e. opening and closing shades) is utilized. Glass areas (as a % of floor area) and glazing U-values (including frame) are shown below.

**GLASS AREA AND GLASS U-VALUE BY VINTAGE
MULTI-FAMILY UNIT**

Glass Area (% of floor)		Glass U-Value	
EXISTING	NEW	EXISTING	NEW
14.9	11.9	1.31	1.31

The unit is assumed to be surrounded by a limited amount of shading that represents a generic combination of some adjacent buildings and nearby trees. Other shading-related inputs, such as terrain and shielding factors correspond to a suburban setting with low buildings.

The Hawaii Model Energy Code is written such that there exists a maximum allowable Relative Solar Heat Gain (RSHG) based upon the window to wall ratio (WWR) of the structure. Since the WWR for our multi-family prototype is .10, the maximum allowable RSHG is 1.0 for north facing walls and .85 for east,

west, and south facing walls. The RSHG is a linear function of the shading coefficient of glass on the relevant wall, the shading coefficient of exterior shade screens, the shading coefficient of the interior screens, and the overhang projection factor. A combination of these factors are incorporated into the NEW vintage of the multi-family prototype to yield the appropriate RSHG value.

The following table presents a summary of the annual energy use for the various multi-family models. The target energy use values are from ENERGY 2020 and HECO's REEPS Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). As with Single Family, it should be noted that target values were only available for new and existing homes combined. The DSM parametric analysis, on the other hand, requires values specific to new and existing homes. CAC refers to central air-conditioning, RAC refers to room air-conditioning and None in the first column refers to a building model with no air-conditioning. There are no target values for room air-conditioning or exterior lighting energy use.

These data are also presented in the two graphs that follow.

**Summary of Annual Energy Use by Vintage, Fuel Type and Cooling Type
Multi-Family**

	End Use Categories					
	Cooling	DHW	Other-kWh	Other-gas	In-LIGHTS	Ex-LIGHTS
	kWh	kWh or therm	kWh	therms	kWh	kWh
New Vintage Electric House						
Target UECs	2669	1645	5180	0	353	na
Central A/C	2255	1870	4008	0	713	240
Room A/C	776	1870	4008	0	713	240
No A/C		1870	4008	0	713	240
New Vintage Gas Building						
Target UECs	2669	85	4156	49	353	na
Central A/C	2185	145	3037	49	713	240
Room A/C	733	145	3037	49	713	240
No A/C		145	3037	49	713	240
Existing Vintage Electric House						
Target UECs	2669	1645	6317	0	353	na
Central A/C	3603	2618	4648	0	713	240
Room A/C	1255	2618	4648	0	713	240
No A/C		2618	4648	0	713	240
Existing Vintage Gas Building						
Target UECs	2669	85	5196	52	353	na
Central A/C	3769	180	3600	52	713	240
Room A/C	1201	180	3600	52	713	240
No A/C		180	3600	52	713	240

**Annual Energy Use for Multi-Family Electric House
New and Existing Vintages**

**Annual Energy Use for Multi-Family Gas House
New and Existing Vintages**

3.0 COMMERCIAL BUILDING PROTOTYPES

Fifteen commercial building types were defined for the analyses relevant to the technologies and measures appropriate to this sector. This section presents an overview of the data sources examined and assumptions made for the development of the commercial DOE-2.1E prototypes utilized for the baseline and parametric analyses and the baseline Energy Use Index (EUI) values from the DOE-2.1E analysis. The work carried out for the development of the baseline and measure case input files was conducted primarily by the Partnership for Resource Conservation (PRC) in conjunction with NEOS staff.

3.1 Commercial Sector Data Sources And Assumptions

In order to assist in the development of commercial sector baseline prototype characteristics representative of the commercial buildings existing in the four counties in Hawaii (Hawaii, Kauai, Maui, and Honolulu), analyses were required of the on-site surveys performed by NEOS (and analyzed by BCI) in Honolulu and Maui, and the CCIG prototypes developed by NEOS and PRC (1994). Analyses of these databases were conducted to provide specific information on the commercial buildings relevant to the climate regions and vintages associated with this project.

Several different building characteristics were available as variables for analysis in these databases. These analysis points included the delineation of floor space from major categories (restaurant, retail, warehouse, and lodging) into smaller sub-categories (fast food vs. sit down restaurant, small vs. large retail, refrigerated vs. non-refrigerated warehouse, resort vs. hotel), the breakdown of floor space by fuel type (gas vs. electric), and the most common cooling equipment types for each building type. This information was then used to help define characteristics for the commercial prototype buildings. Note, there is also some discussion of California's Title 24 Standards when formulating the CCIG building prototypes that were used as a reference when developing Hawaii's prototypes.

The subsections in this section are presented in the following manner. Section 3.1.1 provides an overview of the various utility surveys and sources that were analyzed. In Section 3.1.2, the average floor space by building type for each of the prototypes. In Section 3.1.3, the cooling equipment types found in the various building types are presented. Finally, Section 3.1.4 provides a comparison of average lighting densities across prototypes and data sources.

3.1.1 Data Sources

The on-site survey performed by NEOS (1994) and analyzed by BCI (1994) and the PG&E On-Site Survey (a primary source for the CCIG prototypes devised by NEOS and PRC (1994)) were considered the most reliable and valid in terms of data quality for use in devising the Hawaii prototypes, yet a bit problematic in terms of representativeness of market segment population. The PG&E survey (used in the CCIG prototypes) supplemented the NEOS survey since the sample size of the NEOS survey (from which the BCI prototypes were derived) was small (n=50). Of the mail surveys cited in Table 3-2, the SDG&E Mail Survey (another source for the CCIG prototypes) was considered the most reliable, since considerable effort had been expended cleaning and validating the data prior to combining the 1988 and 1990 surveys.

The PG&E and SCE Mail Surveys, whose results are also presented in Table 3-2, were considered secondary sources for the CCIG prototypes (which, in turn, are considered secondary sources for the Hawaii prototypes).

3.1.2 Average Floor Space

To aid in the determination of appropriate building sizes for the prototype buildings, all of the databases were examined for the average floor area by building type. These data are presented in Tables 3-1 and 3-2. Where significant missing or unreliable floor space data were present, the results are designated as NA or not available. As evident, the floor space estimates vary (significantly in some cases) between the different databases. On the whole, however, the data contain no evidence to suggest any strong relationship between building size, utility service area, and vintage. Consequently, the baseline building prototypes were defined with similar footprint configurations for all vintages and climate regions. In most cases, the average floor space for the Hawaii prototypes was taken from the BCI prototypes. In situations where the BCI data were missing, CCIG prototypes were used.

TABLE 3-1
AVERAGE FLOOR SPACE BY BUILDING TYPE
(DATA USED TO DEVELOP THE HAWAII PROTOTYPES)

Building Type	Hawaii Prototype Building	BCI Prototype Building	CCIG Prototype Building
Large Office	330,000	353,000	175,000
Small Office	10,000	NA	10,000
Large Retail	72,000	72,000	120,000
Small Retail	2,000	NA	8,000
Fast Food Restaurant	1,500	NA	2,000
Sit Down Restaurant	3,000	2,600	4,000
Grocery	23,500	23,500	15,000
Refrigerated Warehouse	50,000	NA	50,000
Non-refrig. Warehouse	70,000	NA	70,000
Hospital	258,000	258,000	250,000
School	50,000	24,400	50,000
College	300,000	116,400	300,000
Hotel	537,700	537,700	200,000
Resort	430,900	430,900	NA
Apartment	146,000	146,000	NA

Table 3-1 illustrates that, in general the BCI prototypes (1994) which were developed from the NEOS (1994) on-site surveys were used to estimate the floor space for each of the building types. When data from the BCI analyses were unavailable, NEOS and the PRC used the prototypes developed for the CCIG as a guide for the Hawaii prototypes in accordance with the raw on-site survey data obtained by NEOS (1994) in Honolulu and Maui. The raw on-site survey data were the data BCI used in its analyses to develop its prototypes, as well. Table 3-2 illustrates the data that were used to devise the CCIG prototypes (that were used to assist in the development of the Hawaii prototypes when data were unavailable from Hawaii). Note, the reference to the Standards in Table 3-2 implies the latest version of California's Title 24 Standards.

**TABLE 3-2
AVERAGE FLOOR SPACE BY BUILDING TYPE
(DATA USED TO DEVELOP CCIG PROTOTYPES)**

Building Type	Vintage	PG&E On-Site Survey	PG&E Mail Survey	SCE Mail Survey	SDG&E Mail Survey	CCIG Prototype Building
Large Office	Pre Stand.	349,256	173,489	161,178	NA	175,000
Large Office	Post Stand.	366,669	181,860	187,504	NA	175,000
Small Office	Pre Stand.	8,085	11,585	4,417	NA	10,000
Small Office	Post Stand.	7,320	10,478	6,224	NA	10,000
Large Retail	Pre Stand.	132,127	124,384	189,319	84,724	120,000
Large Retail	Post Stand.	53,410	95,202	100,281	443,226	120,000
Small Retail	Pre Stand.	3,264	11,927	6,305	5,923	8,000
Small Retail	Post Stand.	2,107	14,412	8,643	6,932	8,000
Sit Down Rest.	All	2,783	7,223	7,751	3,725	4,000
Fast Food Rest.	All	1,542	10,450	3,934	2,371	2,000
Grocery	All	7,221	15,153	14,195	NA	15,000
Ref. Warehouse	All	42,811	54,950	34,236	46,363	50,000
Non-ref. Warehouse	All	8,926	101,724	49,602	17,575	70,000
Hospital	All	NA	236,408	296,558	227,826	250,000
School	All	NA	41,360	52,048	56,567	50,000
College	All	NA	289,710	414,545	307,036	300,000
Hotel	All	101,375	297,407	197,783	NA	200,000

3.1.3 Typical HVAC Equipment Types

Analysis of the surveys also provided insight into the types of cooling equipment technologies predominant in the commercial buildings relevant to this study. All of the building types had either direct expansion cooling or water-based chillers as the principal cooling equipment type.

Table 3-3 presents a summary of the cooling equipment types that were defined for the baseline commercial prototypical buildings. Also included in this table, are the assumptions for the HVAC baseline distribution system types relevant to the commercial prototypes, and the associated cooling equipment types. The definitions of the distribution systems were based on engineering experience and knowledge of the typical characteristics of commercial building HVAC system configurations found in Hawaii.

**TABLE 3-3
EQUIPMENT AND FUEL TYPES**

Building Type	Vintage	Cooling Fuel	Cooling Equipment	Distribution Systems
Large Office	Exist	Electricity	Herm. Cent. Chiller	Constant Volume
Large Office	New	Electricity	Herm. Cent. Chiller	VAV System
Small Office	All	Electricity	DX	Pack. Single Zone
Large Retail	Exist	Electricity	Herm. Cent. Chiller	Constant Volume
Large Retail	New	Electricity	Herm. Cent. Chiller	VAV System
Small Retail	All	Electricity	DX	Pack. Single Zone
Fast Food Rest.	All	Electricity	DX	Pack. Single Zone
Sit Down Rest.	Exist	Electricity	DX	Pack. Single Zone
Sit Down Rest.	New	Electricity	DX	VAV System
Grocery	Exist	Electricity	DX	Pack. Single Zone
Grocery	New	Electricity	DX	VAV System
Ref. Warehouse	All	Electricity	DX	Pack. Single Zone
Non-ref. Warehouse	All	Electricity	DX	Pack. Single Zone
Hospital	System 1-All	Electricity	Herm. Chiller	Central Const. Volume
Hospital	System 2-All	Electricity	Herm. Chiller	Central Const. Volume
Hospital	System 3-All	Electricity	Herm. Chiller	Two-Pipe Fan Coil
Hospital	System 4-All	Electricity	Herm. Chiller	Central Const. Volume
Hospital	System 5-All	Electricity	DX	Pack. Single Zone

TABLE 3-3
EQUIPMENT AND FUEL TYPES (Continued)

School	All	Electricity	DX	Pack. Single Zone
College	System 1-Exist	Electricity	Herm. Chiller	Constant Volume
College	System 1-New	Electricity	Herm. Chiller	VAV System
College	System 2-All	Electricity	Herm. Chiller	Two-Pipe Fan Coil
College	System 3-All	Electricity	DX	Pack. Single Zone
College	System 4-All	Electricity	DX	Pack. Single Zone
Hotel	System 1-Exist	Electricity	Herm. Chiller	Constant Volume
Hotel	System 1-New	Electricity	Herm. Chiller	VAV System
Hotel	System 2-All	Electricity	DX	Pack. Single Zone
Hotel	System 3-All	Electricity	Herm. Chiller	Two-Pipe Fan Coil
Resort	System 1-Exist	Electricity	Herm. Chiller	Constant Volume
Resort	System 1-New	Electricity	Herm. Chiller	VAV System
Resort	System 2-All	Electricity	DX	Pack. Single Zone
Resort	System 3-All	Electricity	Herm. Chiller	Two-Pipe Fan Coil
Apartment	System 1-All	Electricity	Cent. Chiller	Two-Pipe Fan Coil
Apartment	System 2-All	Electricity	DX	Pack. Term. AC

3.1.4 Typical Lighting Densities

Tables 3-4 and 3-5 present the average whole-building lighting densities utilized for the Hawaii prototypes and includes comparisons of these values with estimates derived by BCI from the on-site survey data, as well as the values included in the CCIG prototypes..

TABLE 3-4
AVERAGE LIGHTING DENSITY (WATTS/SF) BY BUILDING TYPE AND VINTAGE

Building Type	Hawaii Exist	Hawaii New	BCI All	CCIG Exist	CCIG New
Large Office	1.68	1.59	1.69	1.90	1.63
Small Office	1.50	1.41	NA	1.91	1.41
Large Retail	1.51	1.21	1.51	1.65	1.16
Small Retail	2.04	1.43	NA	2.04	1.43
Fast Food Restaurant	.95	.72	NA	2.49	1.87
Sit-Down Restaurant	2.50	1.67	1.58	.95	.70
Grocery	1.56	1.26	2.80	1.49	.91
Ref. Warehouse	.84	.58	NA	.85	.59
Nonrefrig. Warehouse	1.09	.85	NA	1.08	.85
Hospital	2.01	1.95	1.22	1.97	1.91
School	1.54	1.50	1.74	1.44	1.40
College	1.00	1.04	1.9	.98	1.03
Hotel	1.52	1.31	.42	1.42	1.25
Resort	1.53	1.32	1.08	NA	NA
Apartment	1.01	.85	.99	NA	NA

A more specific analysis of the lighting densities by zone within the commercial building types follows in Section 3.2. A detailed listing of the lighting technologies assumed for the baseline building prototype is contained in Appendix A.

**TABLE 3-5
AVERAGE LIGHT DENSITY (WATTS/SF) BY BUILDING TYPE AND VINTAGE**

Building Type	PG&E On-Site Data		CCIG Prototype Building	
	Pre Standards	Post Standards	EXS Vintage	NEW Vintage
Large Office	1.82	1.54	1.90	1.63
Small Office	2.55	2.11	1.91	1.41
Large Retail	2.16	1.65	1.65	1.16
Small Retail	2.44	3.26	2.04	1.43
Sit Down Restaurant	1.59	1.37	0.95	0.70
Fast Food Restaurant	2.60	2.43	2.49	1.87
Grocery	2.01	2.50	1.49	0.91
Refrigerated Warehouse	1.43	0.75	0.85	0.59
Non-Refrigerated Warehouse	1.66	1.72	1.08	0.85
Hospital	NA	NA	1.97	1.91
School	NA	NA	1.44	1.40
College	NA	NA	0.98	1.03
Hotel	1.29	1.12	1.42	1.25

The reference in Table 3-5 to Standards implies the latest version of California's Title 24 Standards.

3.2 Commercial Building Types

The prototype for each of the commercial building types for Hawaii is described in detail in the following section. The physical characteristics and geometry of each building are defined, followed by the HVAC, lighting, and equipment load characteristics.

3.2.1 Large Office

Building I.D.: "LOFF"

Building Description: "Large Office"

The large office building is a 22 story high rise building; each floor contains four perimeter zones and a core zone. The first floor of the building contains a variety of retail stores, including a restaurant.

Large Office: perspective

Large Office: plan of top floors

Large Office: plan of first floor

The aspect ratio (ratio of length to width for the building) has been set to 1.5; this value is chosen so that the percentage of core versus perimeter offices is reasonable. The depth of the perimeter zones has been set to 15 feet to reflect the depth of the perimeter offices. The area of the entire building is 330,000 square feet and is made up of the following areas:

Sales	2.3%
Restaurant	2.3%
Office/Hallways	95%

The exterior walls are assumed to be curtain type walls, composed of a spandrel type exterior finish, and a gypsum board interior finish. The roof is made up of built-up roofing and a concrete deck. Roof insulation is included in the new vintage.

The overall fenestration fraction is set at 0.55, with slightly less in the retail and restaurant. The typical window type consists of tinted, single pane glass in the new vintage and clear glass in the existing vintage; all windows are inoperable.

A central plant containing two hermetic centrifugal chillers serves the entire building using a constant volume distribution system in the existing vintage and a variable volume system in the new vintage. A full description of the HVAC specifications is provided in the following tables.

Sixteen large water heaters are located throughout the building, hot water circulation pumps provide ready hot water to all offices.

BASE CASE HVAC PROTOTYPE SPECIFICATIONS LARGE OFFICE

HVAC System-1	Dist Type	Area Served	Cooling Type
Existing Vintage	Constant Vol.	330,000	Herm Cent Chiller
New Vintage	VAV	330,000	Herm Cent Chiller

HVAC Controls	Vintage	
	Existing	New
Cooling kW/ton	0.85	0.75
Cooling Tons	1350	1070
Economizer type	none	temperature
Chilled Water reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
Fan Control	const vol.	inlet
Design Duct DT (°F)	5	3

Two cooling setpoints have been defined; a daytime setpoint and a nighttime set up.

Setpoint	Zones/spaces	Initial setpoint: Clg
csp0	setup used throughout building	95° F
csp1	normal setpoints	72° F

The office building has separate schedules to control occupancy, lighting, equipment and infiltration in each of the zones; schedules are modified for Saturdays, Sundays and holidays.

A single lighting density and schedule are used for all of the office zones in the building. Equipment (plug loads) are handled in the same way. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. Equipment EUIs are assumed to not vary significantly by vintage in the office building.

zone description	Lighting Watts/sqft	
	Existing	New
Office	1.80	1.50
Retail	3.10	2.50
Kitchen	1.40	1.20
Dining	1.30	0.80
Exterior Lighting	0.253	0.211

zone description	Equipment Watts/sqft	
	Existing	New
Office	1.33	1.33
Retail	1.20	1.20
Kitchen	2.40	2.40
Dining	0.60	0.60

Refrigeration is not explicitly modeled in the office building; rather, it is included in the overall equipment loads of the building. The core zones include 200 CFM of exhaust air for the restrooms.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

**TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE
LARGE OFFICE**

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	6.00	4.40	14.63	1.49	0.99	1.18
EXISTING	6.07	5.10	10.21	4.13	0.96	1.15
NEW	5.03	5.10	6.02	2.25	0.87	1.15

While the cooling end-use EUI is somewhat lower than the target, the sum of the cooling and ventilation categories is approximately correct.

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
LARGE OFFICE**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	0.87	0.054
EXISTING	0.96	0.077

3.2.2 Small Office

Building I.D.: "SOFF"

Building Description: "Small Office"

The small office building is a two-story, rectangular building ; each floor contains four perimeter zones and a core zone.

Small Office: perspective

Small Office: plan

The aspect ratio has been set to 1.5; this value is chosen so that the percentage of core versus perimeter offices is reasonable. The depth of the perimeter zones has been set to 15 feet. The total area of the building is 10,000 square feet. The areas of the individual zones are determined by the aspect ratio and office depth.

Building Areas	Total Area	Exterior Wall Area	Window Area	Roof Area	Ground Area
	10000	5369	1559	5000	5000

The exterior walls are assumed to be cement, insulation (new vintage only) and a gypsum board finish. The roof is made up of built-up roofing, insulation (new vintage only) and a wood deck.

The overall fenestration fraction is set at 0.30. Window maintenance (i.e. opening and closing shades) is utilized. The typical glass type is single-pane clear glass.

Two rooftop systems (PSZ) serve the office building; one system serves the first floor and the other serves the second floor.

A 30 gallon gas water heater on each floor of the office building supplies all of the hot water requirements.

BASE CASE HVAC PROTOTYPE SPECIFICATIONS SMALL OFFICE

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1	PSZ	floor 1	5000	DX
System 2	PSZ	floor 2	5000	DX

HVAC Efficiencies/Controls	Vintage	
	Existing	New
Cooling COP	2.25	2.9
Cooling Tons - System 1	24	17
Cooling Tons - System 2	24	18
Economizer Type	none	temperature
Fan Control	const. vol.	const vol.
Design Duct DT (°F)	2.5	1

Two cooling setpoints have been defined; a daytime setpoint and a nighttime set up.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used throughout building	95° F
csp1	normal setpoints	77° F

The office building has separate schedules to control occupancy, lighting, equipment and infiltration in each of the zones; schedules are modified for Saturdays, Sundays and holidays.

A single lighting density and schedule are used for all zones in the building. Equipment (plug loads) are handled in the same way. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. Equipment EUIs are assumed not to vary significantly by vintage in the office building.

zone description	Lighting Watts/sqft	
	Existing	New
Office	1.55	1.30
Exterior Lighting	0.17	0.156

zone description	Equipment Watts/sqft	
	Existing	New
Office	0.70	0.70

Refrigeration is not explicitly modeled in the office building; rather, it is included in the overall equipment loads of the building. The core zones include 200 CFM of exhaust air for restrooms.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE SMALL OFFICE

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	3.91	2.90	9.55	0.97	0.65	0.77
EXISTING	4.05	2.75	9.88	1.68	0.65	0.78
NEW	3.39	2.75	6.30	1.90	0.59	0.78

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
SMALL OFFICE**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	0.59	0.033
EXISTIN G	0.65	0.045

3.2.3 Large Retail

Building I.D.: "LRET"

Building Description: "Large Retail"

The large retail building is a separate (i.e. not part of a mall) two-story building, dominated by showrooms with storage areas on both floors and an office on the top floor.

Large Retail: perspective

The area of the building is 72,000 square feet, with an aspect ratio of 3.0 (ratio of length versus width). The areas of the individual zones are determined by assigning a percentage to the various zones. The following list is the assignment of percentages.

Sales	80%	of total area
Offices	5%	of total area
Storage	15%	of total area

The exterior walls are assumed to be composed of concrete block and a gypsum board finish. The roof is made up of built-up roofing, insulation (new vintage only) and a concrete deck.

A single fenestration fraction is used for the office area; the fenestration fraction refers to the fraction of the exterior wall in a given area that is window. This value has been set to 0.3. The entrance of the building is the only other window area in the building, and has a six-foot setback.

Window maintenance (i.e. opening and closing shades) is not utilized. The typical glass type is single-pane clear glass.

A single reciprocating chiller serves the building with a constant volume distribution system in the Existing vintage and a variable air volume distribution system in the New vintage. Two 100 gallon water heaters supply the hot water for the large retail store.

**BASE CASE HVAC PROTOTYPE SPECIFICATIONS
LARGE RETAIL**

HVAC System-1	Dist Type	Area Served	Cooling Type
Existing Vintage	Constant Vol.	72000	Herm Recip Chiller
New Vintage	VAV	72000	Herm Recip Chiller

HVAC Controls	Vintage	
	Existing	New
Cooling kW/ton	0.95	0.90
Cooling Tons	160	154
Economizer type	none	temperature
Chilled Water reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
Fan Control	const vol.	inlet
Design Duct DT (°F)	5	3

Three cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used throughout building	85° F
csp1	showrooms, offices	73° F
csp2	storage areas	80° F

The store operates on an 8:30 a.m. - 8:30 p.m. schedule, except Christmas holiday hours which are 8:30 a.m. to 10:30 p.m.. Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020.

zone description	Lighting Watts/sqft	
	Existing	New
Sales	2.20	1.80
Office	1.40	1.20
Storage	0.60	0.50
Exterior Lighting	0.383	0.325

zone description	Equipment Watts/sqft	
	Existing	New
Sales	0.9	0.9
Office	1.13	1.13
Storage	0.23	0.23

Refrigeration is not explicitly modeled in the store; rather, it is included in the overall equipment loads of the building.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE LARGE RETAIL

kWh/ft ² /yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	5.58	4.39	13.01	1.55	1.19	1.76
EXISTING	9.28	4.55	10.97	3.25	1.21	1.76
NEW	7.00	4.55	7.47	1.59	1.16	1.49

The lighting EUI is somewhat higher than the target, but since minimal realistic lighting densities and schedules were used in the model, no further adjustments were made. While the cooling is somewhat low compared to the target value, the sum of cooling and ventilation is very close to the sum of the target values.

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
LARGE RETAIL**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	1.16	0.053
EXISTING	1.21	0.060

3.2.4 Small Retail

Building I.D.: "SRET"

Building Description: "Small Retail"

The small retail building is modeled as part of a strip mall (i.e. other buildings on two sides); it is a two-story building with showroom and storage areas on each floor.

SMALL RETAIL: perspective

SMALL RETAIL: plan

The floor area of the small retail establishment is 2,000 square feet. The aspect ratio (ratio of length versus width) has been set to 2.0. 80% of the total area is assigned to sales space, the remaining area is used for storage.

Building Areas	Total Area	Exterior Wall Area	Window Area	Roof Area	Ground Area
	2000	1610	537	2000	1000

The exterior walls are assumed to be composed of concrete and a gypsum board finish. The roof is made up of built-up roofing and a wood deck.

A single fenestration fraction is used for the store front; the fenestration fraction refers to the fraction of the exterior wall in a given area that is window. This value has been set to 0.6. The entrance of the building is included in this glazing area.

Window maintenance (i.e. opening and closing shades) is not utilized. The typical glass type is single-pane clear glass.

Two rooftop units serve the store (one for each floor) and two 10 gallon water heaters supply the hot water for the store.

BASE CASE HVAC PROTOTYPE SPECIFICATIONS SMALL RETAIL

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1	PSZ	sales/stor	1000	DX
System 2	PSZ	sales/stor	1000	DX

HVAC Efficiencies/Controls	Vintage	
	Existing	New
Cooling COP	2.25	2.9
Cooling Tons - System 1	6.0	4.8
Cooling Tons - System 2	6.0	5.0
Economizer Type	none	temperature
Fan Control	const. vol.	const vol.
Design Duct DT (°F)	2.5	1

Three cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clgl setpoint
csp0	setup used throughout building	95° F
csp1	showroom	77° F
csp2	storage	85° F

The store operates on an 9 a.m. - 9 p.m. schedule, with somewhat longer weekend and holiday hours. Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020.

zone description	Lighting Watts/sqft	
	Existing	New
showroom	2.20	1.80
storage	0.60	0.50
Exterior Lighting	0.38	0.38

zone description	Equipment Watts/sqft	
	Existing	New
showroom	1.0	0.8
storage	0.2	0.2

Refrigeration is not explicitly modeled in the store; rather, it is included in the overall equipment loads of the building.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE SMALL RETAIL

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	5.58	4.39	13.01	1.55	1.19	1.76
EXISTING	8.00	4.43	15.48	1.63	1.22	1.75
NEW	6.56	3.59	9.55	1.83	0.52	1.75

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
SMALL RETAIL**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	0.52	0.038
EXISTING	1.22	0.065

3.2.5 Fast-Food Restaurant

Building I.D.: "FFRE"

Building Description: "Fast-Food Restaurant"

The fast-food restaurant is one-story building with four zones: the entry, the kitchen, the dining room and a restroom.

FAST FOOD RESTAURANT: Perspective

The area of the building is 1,500 square feet. The aspect ratio has been set to 1.0, giving equal exterior wall exposure to all orientations. The areas of the individual zones are determined by assigning a percentage to the various zones. The following list is the assignment of percentages.

Entry	15%	of total area
Kitchen	30%	of total area
Restroom	5%	of total area
Dining	50%	(remainder of total area)

The exterior walls are assumed to be composed of concrete with a gypsum board finish. The roof is made up of built-up roofing, and concrete.

A single fenestration fraction value is utilized for the restaurant; this value is used for the dining room and entry, no windows are assumed for the restroom and the kitchen. The value used is 0.25.

Window maintenance (i.e. opening and closing shades) is not utilized. The typical glass type is single-pane clear glass.

Two packaged roof-top systems (PSZ) service the restaurant, one serves the kitchen and another serves the dining room, entry and restroom.

A 60 gallon gas water heater with a recovery rate of 110,000 BTU/hr supplies all of the hot water for the restaurant.

BASE CASE PROTOTYPE SPECIFICATIONS FAST FOOD RESTAURANT

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1	PSZ	kitchen	375	DX
System 2	PSZ	dining	1125	DX

HVAC Efficiencies/Controls	Vintage	
	Existing	New
Cooling COP	2.25	2.9
Cooling Tons - System 1	6.0	3.1
Cooling Tons - System 2	6.0	4.8
Economizer Type	none	temperature
Fan Control	const. vol.	const vol.
Design Duct DT (°F)	2.5	1

Three cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used throughout building	85° F
csp1	dining,restroom,entry	78° F
csp2	kitchen	82° F

The restaurant has separate schedules to control occupancy, lighting, equipment and infiltration in each of the zones; schedules are modified for Saturdays, Sundays and holidays. The basic schedule is from 11 a.m. to midnight.

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
entry	1.00	0.50
kitchen	1.20	1.00
dining	1.40	0.96
restroom	1.20	0.80
Exterior Lighting	0.70	0.70

zone description	Equipment Watts/sqft	
	Existing	New
entry	0.0	0.0
kitchen	3.0	2.75
dining	0.75	0.5
restroom	0.15	0.1

Refrigeration loads are modeled as a freezer at -10° F and a medium temperature refrigerator at 40°F located in the kitchen area. The amount of refrigeration energy use is based upon the results of the Energy 2020 EUI's. The kitchen and the restroom have separate exhaust fans. The net exhaust rate is set at 1.5 CFM per square foot of space for the kitchen, the overall hood supply and exhaust rate is 7.5 CFM per square foot of kitchen area; 200 CFM of exhaust if modeled for the restroom.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE FAST FOOD RESTAURANT

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG	REFRIG
TARGET	5.19	18.14	11.87	1.92	6.91	1.28	5.31
EXISTING	5.25	17.63	15.76	5.28	1.74	3.22	5.51
NEW	3.80	16.27	10.34	4.69	1.37	3.22	5.54

**Fast-Food Restaurant EUI Summary
Existing Vintage**

Since the same target values are used for both the fast-food and sit-down restaurants, some allowance is made in certain end-use categories to account for the differences between the two restaurant types. Hot water use is set to be lower than average restaurant use, since dishwashing is not a major energy use, also, exterior lighting is set to be somewhat higher (per square foot) than an average restaurant to account for the typically small floor area and larger amount of exterior lighted signs.

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

**End Use by Vintage
Fast-Food Restaurant**

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**Service Hot Water Energy Use by Vintage and Fuel Type
Fast Food Restaurant**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	1.37	0.10
EXISTING	1.74	0.16

3.2.6 Sit-Down Restaurant

Building I.D.: "SDRE"

Building Description: "Sit-Down Restaurant"

The sit-down restaurant is a one-story building with four zones: the entry, the kitchen, the dining room and a restroom. It is similar in characteristics to the fast-food restaurant with somewhat different building geometry, zonal fractions, and, most significantly, energy intensities and operating schedules.

SIT-DOWN RESTAURANT: Perspective

The building area is 3000 square feet. The aspect ratio has been set to 1.5, giving equal exterior wall exposure to all orientations. The areas of the individual zones are determined by assigning a percentage to the various zones. The following list is the assignment of percentages.

Entry	10%	of total area
Kitchen	25%	of total area
Restroom	5%	of total area
Dining	60%	(remainder of total area)

The exterior walls are assumed to be composed of brick, concrete, and a gypsum board finish. The roof is made up of built-up roofing and a wood deck.

A single fenestration fraction of 0.25 is utilized for the restaurant; this value is used for the dining room and entry. No windows are assumed for the restroom and one window is placed in the kitchen.

Window maintenance (i.e. opening and closing shades) is not utilized. The typical glass type is single-pane clear glass.

Two packaged roof-top systems (PSZ) service the restaurant, one serves the kitchen and another serves the dining room, entry and restroom. A 100 gallon water heater supplies all of the hot water for the restaurant.

**BASE CASE PROTOTYPE SPECIFICATIONS
SIT-DOWN RESTAURANT**

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1	PSZ	kitchen	900	DX
System 2	PSZ	dining	2100	DX

HVAC Efficiencies/Controls	Vintage	
	Existing	New
Cooling COP	2.25	2.9
Cooling Tons - System 1	4.0	4.6
Cooling Tons - System 2	8.0	5.7
Economizer Type	none	temperature
Fan Control	const. vol.	const vol.
Design Duct DT (°F)	2.25	1

Three cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used throughout building	85° F
csp1	dining, restroom, entry	78° F
csp2	kitchen	85° F

Schedules are modified for Saturdays, Sundays and holidays. The basic schedule is from 8 a.m. to midnight. Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
entry	1.00	1.00
kitchen	1.36	1.10
dining	1.20	0.90
restroom	1.40	0.92
Exterior Lighting	0.28	0.28

zone description	Equipment Watts/sqft	
	Existing	New
entry	0.0	0.0
kitchen	4.5	4.0
dining	1.5	1.5
restroom	0.2	0.1

Refrigeration loads are modeled as a freezer at -10° F and a medium temperature refrigerator at 40° F located in the kitchen area. The amount of refrigeration energy use will be based upon the results of the Energy 2020 EUI's. The kitchen and the restroom have separate exhaust fans. The net exhaust rate is set at 1.5 CFM per square foot of kitchen area, with the overall hood supply and return CFM set at 7.5 CFM per square foot of kitchen area; 200 CFM of exhaust is modeled in the restroom.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE SIT-DOWN RESTAURANT

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG	REFRIG
TARGET	5.19	18.14	11.87	1.92	6.91	1.28	5.31
EXISTING	5.73	12.88	10.56	4.65	6.90	1.29	5.23
NEW	4.50	12.04	7.14	1.73	6.50	1.29	5.41

**Sit Down Restaurant EUI Summary
Existing Vintage**

Equipment usage in the sitdown restaurant is set to be somewhat less than the average restaurant, accounting for the larger dining area than in fast-food type restaurants.

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
SIT-DOWN RESTAURANT**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	6.50	0.33
EXISTING	6.90	0.41

3.2.7 Grocery

Building I.D.: "GROC"

Building Description: "Grocery"

The grocery store is a supermarket-type store with an office area, a storage area, a bakery, three temperatures of refrigeration casework in the sales area and a separate cashier section at the front of the store. The basic description of the grocery store is taken from the report "Characterization of Building Prototypes" by Barakat and Chamberlin, Inc. (2-25-94). A secondary data source for the development of the grocery store model is the grocery store prototype developed for the CCIG.

GROCERY: perspective

GROCERY: plan

The aspect ratio (ratio of length to width of the building) is set to 1.0 so that the exterior walls have equal exposure to all orientations. The floor area of the building is 23,500 square feet and is made up of the following areas:

Bakery	3%	of total area
Office	2%	of total area
Storage	15%	of total area
Cashier area	10%	of total area
Sales area	70%	of total area

The exterior walls are assumed to be composed of brick, concrete block, insulation (new vintage only) and a gypsum board finish. The roof is made up of built-up roofing, and insulation (new vintage only) over a wood deck. The window-to-wall ratio is set to 0.16, with the inoperable windows being composed of single-pane clear glass.

The HVAC system consists of three packaged rooftop systems with direct-expansion cooling and air-cooled condensers. The supply air is delivered at a constant volume in the existing building model and at a variable rate in the new building model. A single rooftop unit serves the sales area; another rooftop unit serves the storage and offices, and a third serves the bakery and cashier areas. A total of 350 gallons of hot water heaters supply hot water for the store.

BASE CASE PROTOTYPE SPECIFICATIONS GROCERY STORE

HVAC Systems	System Type	Area Served Desc	Cooling Type
System 1	PSZ	sales	DX
System 2	PSZ	cashier/bakery	DX
System 3	PSZ	stock/office	DX

HVAC Efficiencies/Controls	Vintage	
	Existing	New
Cooling COP	2.25	2.9
Cooling Tons - System 1	18	16
Cooling Tons - System 2	20	13
Cooling Tons - System 3	20	13
Economizer Type	none	temperature
Fan Control	const vol.	VAV
Design Duct DT (°F)	2.5	1

Four cooling setpoints are defined and described below.

Setpoint	Zones/spaces	Cooling Setpoint
csp1	sales, cashier areas	73
csp2	stockroom	74
csp3	offices	73
csp4	bakery	73

The store operates 24 hours a day, with minimal night-time use. Separate schedules control occupancy, lighting, equipment and infiltration in each of the zones.

Basic Schedules

Bakery	5a - 5p
Office	9a - 5p
Storage	24 hours
Cashier area	24 hours
Sales area	24 hours

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
bakery	1.20	1.00
office	1.50	1.20
cashier area	1.32	1.10
storage	1.02	0.80
sales area	1.65	1.28
Exterior Lighting	0.30	0.24

zone description	Equipment Watts/sqft	
	Existing	New
bakery	2.1	2.1
office	1.1	1.1
cashier area	1.8	1.8
storage	0.9	0.9
sales area	1.1	1.1

Refrigeration is explicitly modeled in the grocery store. Three separate temperatures are assumed for the refrigeration casework: -10°, 22° and 35° F corresponding to frozen food casework, meat casework and

produce casework. The loads corresponding to the three temperatures are based upon the area of the sales floor. Initial load estimates are based on the following equations derived from previous modeling efforts:

load of -10° casework = $-4.5 \times \text{sales area}$ (BTU/hr)

load of 22° casework = $-3.5 \times \text{sales area}$ (BTU/hr)

load of 35° casework = $-10.0 \times \text{sales area}$ (BTU/hr)

The defrost mechanism for the frozen food is assume to be thermostatically controlled resistance heating for the EXISTING vintage and hot gas for the NEW vintage; the meat casework is assumed to have a timer controlled off-time for defrost in the EXISTING vintage, the NEW vintage uses thermostatically controlled hot gas defrost.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE GROCERY

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG	REFRIG
TARGET	10.59	7.51	13.31	2.37	2.39	1.36	25.79
EXISTING	11.61	7.56	6.11	1.89	2.13	1.38	25.62
NEW	9.08	7.56	3.48	1.80	1.10	1.38	25.70

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
GROCERY**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	1.10	0.07
EXISTING	2.13	0.09

3.2.8 Refrigerated Warehouse

Building I.D.: "RWAR"

Building Description: "Refrigerated Warehouse"

The refrigerated warehouse has five zones: an office area, a dock area, and three refrigerated areas maintaining different temperatures: a freezer at -10° F, a meat/deli section at 30° F and a produce section at 40° F .

REFRIGERATED WAREHOUSE: perspective

REFRIGERATED WAREHOUSE: plan

The area of the building is 50,000 square feet. The aspect ratio has been set to 1.25, creating a building 200 by 250 feet with the long axis running east-west. The areas of the individual zones are determined by assigning a percentage of total floor area to the various zones. The following list is the assignment of percentages.

Office area	2% of total area (two-stories, or 2000 sqft total)
Dock area	8% of total area (4000 sqft)
Freezer area	40% of total area (20,000 sqft)
Meat/Deli area	20% of total area (10,000 sqft)
Produce area	30% of total area (15,000 sqft)

Building Areas	Total Area	Exterior Wall Area	Window Area	Roof Area	Ground Area
	50000	25710	210	50000	50000

Roof and wall insulation values are summarized in the table below. The exterior walls are assumed to be composed of tilt-up concrete panels with Extruded PolyStyrene (EPS) insulation for insulating material. The roof is made up of built-up roofing and EPS insulation and a plywood deck. The freezer floor includes five inches of concrete over four inches of high density urethane or styrofoam insulation.

Area	Wall Insulation		Roof Insulation	
	Existing	New	Existing	New
Office	14.4	24	14.4	24
Dock	14.4	24	14.4	24
Produce	14.4	24	14.4	24
Freezer	14.4	24	19.2	32
Meat/deli	14.4	24	14.4	24

Windows are located only in the office area, the office fenestration fraction has been set to 0.3, the entrance of the building is included in this glazing area.

Window maintenance (i.e. opening and closing shades) is utilized. Single pane, clear glass is used in the operable windows.

A single rooftop unit (PSZ) serves the office area; a central ammonia system supplies cooling for the three storage areas and the dock. A 50 gallon hot water heater supplied hot water for the warehouse.

**BASE CASE PROTOTYPE SPECIFICATIONS
REFRIGERATED WAREHOUSE**

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1	PSZ	office	1000	DX

HVAC Efficiencies/Controls	Vintage	
	Exs	New
Cooling COP	2.25	2.9
Cooling Tons	3.0	2.3
Economizer Type	none	temperature
Fan Control	const vol.	const vol.

Six cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used in office	85° F
csp1	office	76° F
csp2	freezer area	-10 ° F
csp3	meat/deli area	30 ° F
csp4	produce area	40° F
csp5	dock area	55 ° F

The warehouse has schedules for each of its major areas; separate schedules control occupancy, lighting, equipment and infiltration in each of the zones. The office and service areas operate on an 8 A.M. - 6 P.M. schedule, five days per week.

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. The assignments are listed below.

zone description	Lighting Watts/sqft	
	Existing	New
office	1.36	1.15
dock area	1.26	0.98
refrigerated areas	1.00	0.65
Exterior Lighting	0.09	0.09

zone description	Equipment Watts/sqft	
	Existing	New
office	1.50	1.50
dock area	8.79	8.79
refrigerated areas	0.00	0.00

Exterior lighting and domestic hot water requirements are assigned so as to match estimated EUIs.

Refrigeration is explicitly modeled in the refrigerated warehouse. The details of this refrigeration equipment are provided in the following tables.

**BASE CASE PROTOTYPE REFRIGERATION EQUIPMENT SPECIFICATIONS
REFRIGERATED WAREHOUSE**

Refrigeration Systems	Area Desc	Area Size	Refrigeration Plant
Refrig 1	dock/deli/prd	29000	Central Recip. Chiller(s)
Refrig 2	freezer	20000	Central Recip. Chiller(s)

Refrigeration Efficiencies/Controls	Vintage	
	Exs	New
Refrig 1		
Cooling Tons	106	106
Space Temperatures (°F)	30/40	30/40
Number of Compressors	1	2
Total Refrigeration Capacity	105 tons	105 tons
Chilled Water Temperature (°F)	15	15
Refrigeration kW/Ton	1.23	1.26
Refrig 2		
Cooling Tons	58	58
Space Temperatures (°F)	-10	-10
Number of Compressors	1	2
Total Refrigeration Capacity	58 tons	58 tons
Chilled Water Temperature (°F)	-25	-25
Refrigeration kW/Ton	2.70	2.75

SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE REFRIGERATED WAREHOUSE

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
EXISTING	3.39	1.35	0.086	0.017	0.37	0.41
NEW	0.08	0.073	0.052	0.019	0.34	0.41

The new vintage includes HVAC equipment improvements, including improvements in the service hot water specifications. There are no target values for the refrigerated warehouse building type.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE REFRIGERATED WAREHOUSE

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	0.34	0.019
EXISTING	0.37	0.025

3.2.9 Non-Refrigerated Warehouse

Building I.D.: "NRWA" Building Description: "Non-Refrigerated Warehouse"

The non-refrigerated warehouse has three zones: an office area, a service, or receiving, area and the main storage area.

STORAGE: perspective

STORAGE: plan

The aspect ratio has been set to 1.0 so that the exterior walls have equal exposure to all orientations.

The area of the building is 70,000 square feet. The areas of the individual zones are determined by assigning a percentage to the various zones. The following list is the assignment of percentages.

Office area	10%	of total area
Service area	10%	of total area
Storage	80%	remainder of area

Building Areas	Total Area	Exterior Wall Area	Window Area	Roof Area	Ground Area
	70000	23160	2239	70000	70000

The exterior walls are assumed to be composed of concrete block and a gypsum board finish. The roof is made up of built-up roofing and a wood deck.

A separate fenestration fraction is used for the office area and the rest of the building; the fenestration fraction refers to the fraction of the exterior wall in a given area that is window. The office fenestration fraction has been set to 0.3, the entrance of the building is included in this glazing area; the remainder of the building has a fenestration fraction of 0.1.

Window maintenance (i.e. opening and closing shades) is not utilized. The typical glass type is single-pane clear glass.

A single rooftop unit (PSZ) serves the office area with DX cooling. A 30 gallon gas water heater supplies all of the hot water for the warehouse.

BASE CASE HVAC PROTOTYPE SPECIFICATIONS NON-REFRIGERATED WAREHOUSE

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1	PSZ	office	7000	DX

HVAC Efficiencies/Controls	Vintage	
	Existing	New
Cooling COP	2.25	2.9
Cooling Tons	12	7.6
Economizer Type	none	temperature
Fan Control	const. vol.	const vol.
Design Duct DT (°F)	2.5	1

Two cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used in office,service	95° F
csp1	office	79° F

The office and service areas operate on a 9 A.M.-5 P.M. schedule, with shorter weekend and holiday hours. Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
office	1.40	1.17
service	1.00	0.70
storage	0.49	0.32
Exterior Lighting	0.096	0.096

zone description	Equipment Watts/sqft	
	Exs	New
office	1.50	1.25
service	1.50	1.20
storage	0.30	0.25

As the equipment load assumptions indicate, the non-refrigerated warehouse building prototype is assumed to be utilized primarily for storage purposes. No major process or motor loads are assumed to be included in the building. While large process and motor loads can exist in a warehouse, these loads are generally considered industrial rather than commercial loads.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE NON-REFRIGERATED WAREHOUSE

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	1.95	2.35	3.77	0.59	0.32	0.44
EXISTING	2.15	2.34	3.57	0.48	0.363	0.44
NEW	1.47	1.93	2.38	0.521	0.281	0.44

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
NON-REFRIGERATED WAREHOUSE**

VINTAGE	ELECTRIC kWh/ft ² /yr	GAS therms/ft ² /yr
NEW	0.028	0.002
EXISTING	0.036	0.004

3.2.10 Hospital

Building I.D.: "HOSP"

Building Description: "Hospital"

The hospital model includes two multi-story buildings both of which include multi-use zones on each floor. Building A contains the emergency rooms and admitting area, the public waiting areas and the maintenance spaces on the first floor. Radiation therapy, diagnostics, labs and surgery are located on the second floor and intensive care with nursing support is located on the top floor. Building B houses the kitchen and cafeteria on the first floor along with the occupational and physical therapy spaces. The second through fifth floors of this building contains the administrative offices and some wards, which are also located on the top floor along with nursing support.

HOSPITAL, Bldg A: perspective

HOSPITAL, Bldg B: perspective

The area of the entire complex is 258,000 square feet. The aspect ratio has been set to 1.5; this value is chosen so that the amount of exterior wall versus zone area is reasonable. The areas of the individual zones are determined by assigning a percentage of each floor to the various zones. The following list is the assignment of percentages.

<u>Building A</u>	<u>First Floor</u>
emergency, lab	17.5%
intensive care	17.5%
engineering/maint, public	65%
	<u>Second Floor</u>
labs, surgery, rad. therapy, diag.	100%
	<u>Third Floor</u>
wards	50%
nursing support	35%
engineering/maint, public	15%

<u>Building B</u>	<u>First Floor</u>
kitchen, cafeteria	16%
occ/phys therapy	34%
engineering/maint, public	50%
	<u>Second - Fifth Floors</u>
admin offices	34%
wards	40%
nursing support	26%
	<u>Top Floor</u>
wards	40%
nursing support	40%
engineering/maint, public	20%

<u>Building Areas</u>	<u>Total Area</u>	<u>Roof Area</u>	<u>Ground Area</u>
Building A	86,000	28,667	28,667
Building B	172,000	57,333	57,333
Total	258,000	86,000	86,000

The exterior walls are assumed to be composed of concrete block, insulation (new vintage only) and a gypsum board finish. The roof is made up of built-up roofing and insulation (new vintage only) over a concrete deck.

Fenestration fractions have been assigned by area usage; the fenestration fraction refers to the fraction of the exterior wall in a given area that is window:

Office/administrative areas:	0.3 fenestration fraction
Wards, Patient rooms:	0.2
Public Spaces:	0.2
Kitchen, Cafeteria	0.1
Intensive Care, Emergency, Labs, Diagnostics, Nursing Support, Surgery	0.1

Window maintenance (i.e. opening and closing shades) is utilized for the single-pane, operable clear windows in the patient rooms and in the offices. All other window types in the hospital are tinted and inoperable.

A packaged system (PSZ) serves the kitchen and cafeteria. A two-pipe fan coil system (TPFC) services the patient rooms and offices while the remainder of the hospital uses a constant volume cooling system. Two centrifugal chillers with cooling tower make up the central plant.

**BASE CASE PROTOTYPE SPECIFICATIONS
HOSPITAL**

HVAC Systems	Dist Type	Area Desc	Area Size	Humidity Control	Cooling Type
System 1	Central/CV	nurse,public, therapy	122,550	no	Herm Chlr
System 2	Central/CV	ICU/emergency	15,050	yes	Herm Chlr
System 3	2-pipe FC	wards/admin	70,520	no	Herm Chlr
System 4	Central/CV	labs/surgery	43,000	yes	Herm Chlr
System 5	PSZ	kitchen	6,880	no	DX

HVAC Efficiencies/Controls	Vintage	
	Exs	New
Systems 1 - 4		
Cooling kW/ton	0.85	0.75
No. of Chillers	2	2
Cooling Tons	820	760
Economizer Type	none	temperature
Chilled Water Reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
Fan Control	const vol.	const vol.
Design Duct DT (°F)	5	3
System 5		
Cooling COP	2.25	2.9
Number of Roof Top Units	1	1
Cooling Tons	23	20
Economizer Type	none	temperature
Fan Control	const vol.	const vol.
Design Duct DT (°F)	2.5	1

Three cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setback and setup used throughout building	80° F
csp1	used throughout hospital	75° F
csp2	kitchen/cafeteria	78° F

The hospital has schedules for each of its major areas; separate schedules control occupancy, lighting, equipment and infiltration in each of the zones; schedules are modified for weekends and holidays.

Basic Schedules (modified hourly)

kitchen,cafeteria area	24 hr
intensive care, emergency, lab area	24 hr
engineering/maint, public area	8a - 8p
admin offices, occ/phys therapy area	8a - 8p
wards, isolation areas area	24 hr
nursing support area	24 hr
labs, surgery, rad. therapy, diag. area	8a - 8p

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. The assignments are listed below.

zone description	Lighting Watts/sqft	
	Existing	New
kitchen,cafeteria	1.50	1.25
emergency	2.30	2.00
lab	1.90	1.60
engineering/maint, public	1.00	0.78
admin offices, occ/phys therapy	1.80	1.30
wards, isolation areas	1.60	1.26
nursing support	2.10	1.80
labs, surgery, rad. therapy, diag.	7.00	6.00
Exterior Lighting	0.12	0.098

zone description	Equipment Watts/sqft	
	Existing	New
kitchen,cafeteria	2.0	2.0
emergency	2.5	2.5
lab	2.5	2.5
engineering/maint, public	0.5	0.5
admin offices, occ/phys therapy	1.0	1.0
wards, isolation areas	6.0	6.0
nursing support	3.0	3.0
labs, surgery, rad. therapy, diag.	4.0	4.0

Exterior lighting and domestic hot water requirements are assigned so as to match the estimated EUIs. Refrigeration is not explicitly modeled in the hospital; rather, it is included in the overall equipment loads of the building. The kitchen has a separate exhaust fan, the exhaust rate is set at 2.5 CFM per square foot of space. All other zones use 100% outside air; humidity control is utilized in all patient and lab areas.

The table and graphs below show the results of the baseline simulations for both the existing and new vintages. There are no target values for the hospital building type.

SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE HOSPITAL

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
EXISTING	11.19	11.63	15.80	3.91	6.38	0.55
NEW	8.77	11.63	11.37	3.51	6.20	0.55

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE HOSPITAL

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	6.20	0.28
EXISTING	6.38	0.31

3.2.11 School

Building I.D.: "SCHL"

Building Description: "School"

The school is a one-story building which includes classroom zones, office areas, a cafeteria with kitchen and a gymnasium. Packaged roof-top systems (PSZ) service the conditioned spaces of the school, which is limited to the administrative offices and make up only a small fraction of the total floor area.

SCHOOL: Perspective

The area of the entire complex is 50,000 square feet. The aspect ratio has been set to 1.5; the areas of the individual zones are determined by assigning a percentage to the various zones. The following list is the assignment of percentages.

Gymnasium	4%	of total area
Cafeteria	5%	of total area
Kitchen	3%	of total area
Offices	8%	of total area
Classrooms	80%	of total area

The exterior walls are composed of brick and concrete block construction, insulation (new vintage only) and a gypsum board finish. The roof is made up of built-up roofing, insulation (new vintage only) and a wood deck.

Fenestration fractions have been assigned by area usage; the fenestration fraction refers to the fraction of the exterior wall in a given area that is window. All windows are operable and use single-pane clear glass.

Classrooms:	0.35 fenestration fraction
Administrative Office areas:	0.20 fenestration fraction
Kitchen/Cafeteria:	0.30 fenestration fraction
Gymnasium:	0.10 fenestration fraction

BASE CASE HVAC PROTOTYPE SPECIFICATIONS SCHOOL

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1	PSZ-1	offices	1,000	DX

HVAC Efficiencies/Controls	Vintage	
	Existing	New
Cooling COP	2.25	2.9
Cooling Tons	20	19
Economizer Type	none	temperature
Fan Control	const vol.	const vol.
Design Duct DT (°F)	2.5	1

Cooling setpoints are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	unoccupied period setup	85° F
csp1	administrative offices	72° F

The primary school has schedules for each of its major areas; separate schedules control occupancy, lighting, equipment and infiltration in each of the zones; schedules are modified for summer sessions, Saturdays, Sundays and holidays.

Basic Schedules (modified hourly, seasonally)

classroom/administrative	8a - 3p
cafeteria	11a - 2p
kitchen	10a-2p
gymnasium	8a - 3p

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
classroom	1.7	1.42
cafeteria	1.2	1.0
kitchen	1.2	1.0
gymnasium	1.0	0.63
offices	1.8	1.5
Exterior Lighting	0.022	0.022

zone description	Equipment Watts/sqft	
	Existing	New
classroom/administrative	0.2	0.2
cafeteria	0.2	0.2
kitchen	3.4	3.4
gymnasium	0.1	0.1

Refrigeration is not explicitly modeled in the school; rather, it is included in the overall equipment loads of the building. The kitchen and the gymnasium have separate exhaust fans. The exhaust rate is set at 2.5 CFM per square foot of kitchen area and 1.0 CFM per square foot of gymnasium. Three 80 gallon water heaters supply hot water to the school.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE SCHOOL

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	1.55	0.84	2.10	0.31	0.41	0.10
EXISTING	2.74	0.86	1.18	0.31	0.40	0.10
NEW	2.27	0.86	0.83	0.35	0.35	0.10

Primary School EUI Summary Existing Vintage

The lighting EUI is somewhat higher than the target, but since minimal realistic lighting densities and schedules were used in the model, no further adjustments were made.

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

End Use by Vintage Primary School

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
SCHOOL**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	0.35	0.023
EXISTING	0.40	0.034

3.2.12 College

Building I.D.: "COLL"

Building Description: "COLLEGE"

The college model includes two separate buildings: the three-story classroom/ administrative building and the two-story dormitory. The main college building is intended to represent a number of building types typical to a large campus or a single large college building.

College: perspective

College: plan of first floor

College: plan of second and third floors

The aspect ratio of the main building is set to 3.0; this value is chosen so that the percentage of core versus perimeter classrooms is typical. The depth of the perimeter zones has been set to 42 feet. The width of the Dormitory has been set at 36 feet. This value reflects the width of two dormitory rooms plus a corridor.

The total area of the entire complex is 300,000 square feet. The areas of the individual zones are determined by assigning a percentage to the various zones. Eighty-seven percent of the total area of the college is classrooms and administrative offices. The following list is the assignment of the remaining percentages.

Dormitory	5% of total area
Gym/Facilities	4% of total area
Cafeteria	3% of total area
Kitchen	1% of total area

30% of the top floor core zone is modeled as a computer room with increased equipment loads and a separate rooftop unit providing 24-hour cooling and humidity control.

The exterior walls are assumed to be composed of brick, concrete block, optional insulation (new vintage) and a gypsum board finish. The roof is made up of built-up roofing, insulation (new vintage) and a concrete deck. The dormitory walls do not include the exterior brick finish.

Fenestration fractions have been assigned by area usage; the fenestration fraction refers to the fraction of the exterior wall in a given area that is window:

Classroom/administrative areas:	0.2 fenestration fraction
Gym/Facilities:	0.1
Kitchen/Cafeteria:	0.1
Dormitory rooms:	0.15

Window operating and maintenance schemes (i.e. opening and closing shades) are utilized in the offices and dormitories, both of which use single-pane tinted glass. Other areas of the college use single-pane clear, inoperable windows.

A two-pipe fan coil (TPFC) system services most of the college, including the dormitory and all of the core zones in the main college building. A central air distribution system serves the perimeter classroom/administrative areas of the college; the existing vintage has constant volume supply flow and the new vintage has variable flow. The kitchen and the computer room are each conditioned by their own packaged system (PSZ). Two air-cooled reciprocating chillers make up the central plant. A hot water boiler with circulation pumps is to supply hot water to the college and dorm.

**BASE CASE PROTOTYPE SPECIFICATIONS
COLLEGE**

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1 - Existing	Constant Vol.	admin/class	179740	Recip Chlr
System 1 - New	VAV	admin/class	179740	Recip Chlr
System 2	TPFC	class/dorm	108040	Recip Chlr
System 3	PSZ	computer	7720	DX
System 4	PSZ	kitchen	4500	DX

HVAC Efficiencies/Controls	Vintage	
	Existing	New
System 1		
Cooling kW/ton	0.95	0.90
Economizer Type	none	temperature
Chilled Water Reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
Fan Control	const vol.	inlet
Design Duct DT (°F)	5	3
System 2		
Cooling kW/ton	0.85	0.75
Economizer Type	n/a	n/a
Chilled Water Reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
Fan Control	const vol.	const vol.
Design Duct DT (°F)	n/a	n/a
Cooling Tons - Systems 1 & 2	440	340
Systems 3 & 4		
Cooling COP	2.25	2.9
Cooling Tons - System 3	60	36
Cooling Tons - System 4	45	43
Economizer Type	none	temperature
Fan Control	const vol.	const vol.
Design Duct DT (°F)	2.5	1

Five cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used throughout college	90 °F
csp1	classrooms, administrative	80 °F
csp2	gym/facilities, kitchen, cafe	85 °F
csp3	computer room	78 °F
csp4	dorm rooms	80 °F

The college has schedules for each of its major areas; separate schedules control occupancy, lighting, equipment and infiltration in each of the zones; schedules are modified for summer sessions, Saturdays, Sundays and holidays.

Basic Schedules (modified hourly, seasonally)

classroom/administrative	8a - 10p
cafeteria	8a - 6p
kitchen	10a-2p, 4p-7p
gym/facilities	8a - 10p
dormitory	24 hrs
computer room	24 hrs

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
classroom/administrative	1.7	1.4
cafeteria	1.1	0.92
kitchen	1.4	1.2
shop	1.0	0.78
dormitory	1.4	1.15
computer room	1.7	1.4
Exterior Lighting	0.05	0.041

zone description	Equipment Watts/sqft	
	Existing	New
classroom/administrative	0.18	0.18
cafeteria	0.18	0.18
kitchen	2.23	2.23
shop	0.89	0.89
dormitory	0.27	0.27
computer room	1.78	1.78

Refrigeration is not explicitly modeled in the college; rather, it is included in the overall building equipment load. Both the kitchen and the shop have separate exhaust fans. The exhaust rate is set at 2.5 CFM per square foot of kitchen area and 1.0 CFM per square foot of shop.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE COLLEGE

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	3.45	1.85	4.67	0.69	0.91	0.22
EXISTING	4.80	1.42	6.42	0.89	0.85	0.23
NEW	3.70	1.42	4.07	0.68	0.48	0.23

The lighting EUI is somewhat higher than the target, but since minimal realistic lighting densities and schedules were used in the model, no further adjustments were made.

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
COLLEGE**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	0.48	0.027
EXISTING	0.85	0.037

3.2.13 Hotel

Building I.D.: "*HOT"

Building Description: "Large Lodging"

The hotel is defined as a multi-story building with occupied and unoccupied bedrooms and corridors on the third story and above, with a lobby, sales area, office area, dining room and kitchen on the first floor and offices, conference rooms and auditoriums on the second floor. A laundry and maintenance room is located in the basement. The basic description of the hotel is taken from the report "Characterization of Building Prototypes" by Barakat and Chamberlin, Inc. (2-25-94). A secondary data source for the development of the hotel model is the hotel prototype developed for the CCIG.

Hotel: perspective
(not to scale)

sales	office		kitchen
lobby		dining rooms	

Hotel: plan of first floor
(not to scale)

offices	conference rooms & auditorium
---------	----------------------------------

Hotel: plan of second floor
(not to scale)

unoccupied rooms	occupied rooms
corridor	
occupied rooms	unoccupied rooms

Hotel: plan of upper floors
(not to scale)

The area of the entire hotel complex is 537,700 square feet. The tower portion of the hotel makes up 74 percent of the total area; this part of the hotel is 60 feet wide, and includes the width of two rooms and a corridor, the lower two floors of the hotel are 146 feet wide.

The areas of the individual zones are listed below:

First floor offices	2% of total area
Retail sales	2% of total area
Lobby	2% of total area
Dining areas	4% of total area
Kitchen	2% of total area
Second floor offices	6% of total area
Conference room and auditorium	6% of total area
Laundry/maintenance	2% of total area
Bedrooms/corridors	74% of total area

The percentage of occupied (versus unoccupied) bedrooms has been set to 75%.

The exterior walls are assumed to be composed of 8" concrete with a gypsum board finish. The roof is made up of built-up roofing, insulation (new vintage only) and a concrete deck.

Fenestration fractions have been assigned by area usage; the fenestration fraction refers to the fraction of the exterior wall in a given area that is window:

bedrooms areas:	0.35 fenestration fraction
corridors:	0.2
lobby:	0.3
restaurant:	0.1
office:	0.2
conference rooms:	0.2

Window maintenance (i.e. opening and closing shades) is utilized. Single-pane, clear glass is used for the operable windows in the existing prototype; tinted glass is used in the new vintage.

A variable volume central distribution system (constant volume in the existing vintage) serves the first two floors except for the dining rooms and kitchen, a number of packaged roof-top units serve the dining rooms and kitchen and a two-pipe fan coil system (TPFC) services all of the bedrooms. Two centrifugal chillers and cooling tower make up the central plant. Gas or electric central water heaters supply the hot water needs for the resort in Oahu, while electric or diesel fuel is used to fire hot water boilers in Maui, Kauai, and Hawaii. Circulation pumps are used to provide hot water to each room.

**BASE CASE PROTOTYPE SPECIFICATIONS
HOTEL**

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1 - Existing	Constant Vol.	first 2 floors	129,000	Herm Chlr
System 1 - New	VAV	first 2 floors	129,000	Herm Chlr
System 2	PSZ	kitchen, dining	32,000	DX
System 3	TPFC	rooms	358,000	Herm Chlr

HVAC Efficiencies/Controls	Vintage	
	Exs	New
System 1		
Cooling kW/ton	0.85	0.75
Economizer Type	none	temperature
Chilled Water Reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
Fan Control	const vol.	inlet
Design Duct DT (°F)	5	3
System 2		
Cooling COP	2.25	2.9
Economizer Type	none	temperature
Fan Control	const vol.	inlet
Design Duct DT (°F)	2.5	1
System 3		
Cooling kW/ton	0.85	0.75
Economizer Type	n/a	n/a
Chilled Water Reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
Fan Control	cycling	cycling
Design Duct DT (°F)	n/a	n/a

HVAC Systems - Cooling Tons		Vintage	
		Exs	New
Hawaii Hotel	Systems 1 & 3	920	610
	System 2	180	150
Kauai Hotel	Systems 1 & 3	760	560
	System 2	180	130
Maui Hotel	Systems 1 & 3	900	590
	System 2	180	135
Oahu Hotel	Systems 1 & 3	850	575
	System 2	180	135

Seven cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used throughout building	95° F
csp1	lobby, office	74° F
csp2	kitchen, maintenance	76° F
csp3	office2, conference	74° F
csp4	occupied bedrooms	74° F
csp5	unoccupied bedrooms	86° F

The hotel has schedules for each of its major areas; separate schedules control occupancy, lighting, equipment and infiltration in each of the zones.

Basic Schedules (modified hourly)

bedroom (occupied)	8p - 9a
lobby	24 hrs
office	8a - 8p
conference rooms	9a - 5p
maintenance	24 hrs
restaurant	8a-11p
retail	9a - 9p
kitchen	7a-11p

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
corridor	1.2	1.0
bedroom (occupied)	1.4	0.80
lobby	1.8	1.50
office	1.5	1.25
conference	1.8	1.50
maintenance	1.0	0.78
restaurant	1.4	1.25
retail	2.4	2.0
kitchen	1.4	1.17
Exterior Lighting	0.10	0.084

zone description	Equipment Watts/sqft	
	Existing	New
corridor	0.43	0.43
bedroom (occupied)	1.3	1.3
lobby	0.54	0.54
office	1.3	1.3
conference	0.54	0.54
maintenance/laundry	2.16	2.16
restaurant	2.16	2.16
retail	1.62	1.62
kitchen	3.78	3.78

Refrigeration is not explicitly modeled in the hotel; rather, it is included in the overall equipment loads of the kitchen. The kitchen and the maintenance area, which includes the laundry, have separate exhaust fans. The exhaust rate is set at 0.5 CFM per square foot of space, 1.0 for the kitchen.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE HOTELS

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	5.40	4.62	8.36	1.11	2.68	0.42
Location	New Vintage					
HAWAII	4.06	4.73	5.66	1.28	2.52	0.46
KAUAI	4.06	4.73	5.22	1.12	2.56	0.46
MAUI	4.06	4.73	5.49	1.23	2.56	0.46
OAHU	4.06	4.73	5.60	1.26	2.52	0.46
Location	Existing Vintage					
HAWAII	5.94	4.73	9.20	2.30	2.72	0.46
KAUAI	5.94	4.73	8.57	2.05	2.77	0.46
MAUI	5.94	4.73	8.98	2.21	2.77	0.46
OAHU	5.94	4.73	9.26	2.26	2.72	0.46

All Hotel EUI Summary New and Existing Vintages

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

End Use by Vintage Average of All Hotels

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE, FUEL TYPE AND LOCATION
HOTELS**

LOCATION	VINTAGE	ELECTRIC kWh/ft2/yr	OTHER therms/ft2/yr
HAWAII	NEW	2.52	0.15
(diesel)	EXISTING	2.72	0.21
KAUI	NEW	2.56	0.15
(diesel)	EXISTING	2.77	0.22
MAUI	NEW	2.56	0.15
(diesel)	EXISTING	2.77	0.22
OAHU	NEW	2.52	0.15
(gas)	EXISTING	2.72	0.21

3.2.14 Resort

Building I.D.: "*RST"

Building Description: "Resort"

The resort is defined as three separate buildings: two ten-story towers with occupied and unoccupied guest rooms and laundry facilities and a lobby building with restaurants, a store, offices and conference rooms. The basic description of the resort is taken from the report "Characterization of Building Prototypes" by Barakat and Chamberlin, Inc. (2-25-94).

Resort Tower (1 of 2)

Resort Lobby Building
(not to scale)

sales	office	dining rooms	kitchen
lobby			

Lobby Building: plan of first floor
(not to scale)

conference rooms	dining room	kitchen
		lounge

Lobby Building: plan of second floor
(not to scale)

unoccupied rooms	occupied rooms	
corridor		
occupied rooms		unoccupied rooms

Resort Tower: plan of upper floors
(1 of 2)

laundry facilities	engineering and maintenance	
corridor		
occupied rooms		unoccupied rooms

Resort Tower: plan of first floor
(1 of 2)

Resort Site Plan

The area of the entire resort complex is 430,900 square feet. The tower portion of the resort makes up 77 percent of the total area; this part of the building is 60 feet wide, and includes the width of two rooms and a corridor. The lobby building is two stories approximately 200 by 250 feet.

The areas of the individual zones are listed below:

First floor offices	2% of total area
Retail sales	2% of total area
Lobby	2% of total area
Dining areas	7% of total area
Kitchens	4% of total area
Conference rooms	6% of total area
Laundry/maintenance	2% of total area
Bedrooms	75% of total area

The percentage of occupied (versus unoccupied) bedrooms has been set to 75%.

The exterior walls are assumed to be 8" with a gypsum board finish. The roof is made up of built-up roofing, insulation (new vintage only) and a concrete deck.

Fenestration fractions have been assigned by area usage; the fenestration fraction refers to the fraction of the exterior wall in a given area that is window:

bedrooms areas:	0.55 fenestration fraction
corridors:	0.2
lobby:	0.35
restaurants:	0.25
office:	0.25
conference rooms:	0.25

Window maintenance (i.e. opening and closing shades) is utilized. Single-pane, clear glass is used for the operable windows in the existing prototype; tinted glass is used in the new vintage.

Packaged roof-top units serve the dining rooms and kitchen while a variable volume central distribution system (constant volume in the existing vintage) serves the remainder of the lobby building and a two-pipe fan coil system (TPFC) services all of the bedrooms. Two centrifugal chillers and cooling tower make up the central plant. Gas or electric central water heaters supply the hot water needs for the resort in Oahu, while electric or diesel fuel is used to fire hot water boilers in Maui, Kauai, and Hawaii. Circulation pumps are used to provide hot water to each room.

BASE CASE PROTOTYPE SPECIFICATIONS RESORT

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1 - Existing	Constant Vol.	Lobby build.	90,489	Herm Chlr
System 1 - New	VAV	Lobby build.	90,489	Herm Chlr
System 2	PSZ	kitchen1	8618	DX
System 3	PSZ	kitchen2	8618	DX
System 4	TPFC	rooms/halls	323,175	Herm Chlr

HVAC Efficiencies/Controls	Vintage	
	Exs	New
System 1		
Cooling kW/ton	0.85	0.75
Economizer Type	none	temperature
Chilled Water Reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
Fan Control	const vol.	inlet
Design Duct DT (°F)	5	3
System 2 & 3		
Cooling COP	2.25	2.9
Economizer Type	none	temperature
Fan Control	const vol.	inlet
Design Duct DT (°F)	2.5	1
System 4		
Cooling kW/ton	0.85	0.75
Economizer Type	n/a	n/a
Chilled Water Reset	no	yes
Chilled Water Pipe Gain (°F)	3	2
Chilled Water Valve Type	3-way	2-way
Fan Control	cycling	cycling
Design Duct DT (°F)	n/a	n/a

HVAC Systems - Cooling Tons		Vintage	
		Exs	New
Hawaii Resort	Systems 1 & 4	700	515
	System 2	45	36
	System 3	55	37
Kauai Resort	Systems 1 & 4	650	525
	System 2	45	44
	System 3	60	46
Maui Resort	Systems 1 & 4	650	535
	System 2	36	42
	System 3	50	44
Oahu Resort	Systems 1 & 4	650	530
	System 2	45	40
	System 3	60	40

Seven cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used throughout building	95° F
csp1	lobby, office	72° F
csp2	kitchen, maintenance	75° F
csp3	lounge, restaurant	72° F
csp4	occupied bedrooms	72° F
csp5	unoccupied bedrooms	85° F

The resort has schedules for each of its major areas; separate schedules control occupancy, lighting, equipment and infiltration in each of the zones.

Basic Schedules (modified hourly)

bedroom (occupied)	8p - 9a
lobby	24 hrs
office	8a - 12a
conference rooms	9a - 5p
maintenance	24 hrs
restaurant	8a-12p
lounge	4p - 2a
retail	9a - 9p
kitchen	7a-2a

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
corridor	1.2	1.0
bedroom (occupied)	1.4	0.8
lobby	1.8	1.5
office	1.5	1.25
conference	1.8	1.5
maintenance	1.0	0.78
restaurant	1.4	1.25
retail	2.4	2.0
kitchen	1.4	1.17
bar	1.0	0.9
Exterior Lighting	0.38	0.33

zone description	Equipment Watts/sqft	
	Existing	New
corridor	0.40	0.40
bedroom (occupied)	1.00	1.00
lobby	0.75	0.75
office	1.20	1.20
conference	2.00	2.00
maintenance/laundry	2.00	2.00
restaurant	1.75	1.75
retail	1.50	1.50
kitchen	4.00	4.00
bar	1.50	1.50

Refrigeration is not explicitly modeled in the resort; rather, it is included in the overall equipment loads of the kitchen. The kitchen and the maintenance area, which includes the laundry, have separate exhaust fans. The exhaust rate is set at 0.5 CFM per square foot of space.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages in each location as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE RESORTS

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	5.58	4.39	13.01	1.55	1.19	1.76
Location	New	Vintage				
HAWAII	3.51	3.78	5.18	1.39	1.35	2.67
KAUAI	3.65	3.93	5.45	1.52	1.37	2.67
MAUI	3.65	3.93	5.34	1.42	1.37	2.67
OAHU	3.65	3.93	5.43	2.49	1.35	2.67
Location	Existing	Vintage				
HAWAII	5.00	3.78	9.02	2.42	1.44	2.67
KAUAI	5.17	3.93	9.73	2.63	1.47	2.67
MAUI	5.17	3.93	9.44	2.49	1.47	2.67
OAHU	5.17	3.93	9.48	2.57	1.44	2.67

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE, FUEL TYPE AND LOCATION
RESORTS**

LOCATION	VINTAGE	ELECTRIC kWh/ft2/yr	OTHER therms/ft2/yr
HAWAII	NEW	1.35	0.08
(diesel)	EXISTING	1.44	0.10
KAUI	NEW	1.37	0.08
(diesel)	EXISTING	1.47	0.10
MAUI	NEW	1.37	0.08
(diesel)	EXISTING	1.47	0.10
OAHU	NEW	1.35	0.08
(gas)	EXISTING	1.44	0.10

3.2.15 Apartments

Building I.D.: "APTM"

Building Description: "Apartments"

The apartment building is defined as a large, multi-story building with retail and office space on the first floor and residences on all other floors. The basic description of the apartment building is taken from the report "Characterization of Building Prototypes" by Barakat and Chamberlin, Inc. (2-25-94).

The area of the entire apartment building is 146,000 square feet. The residence portion of the building (including hallways) makes up 92 percent of the total area; the apartment building is 66 feet wide, and includes the width of two residences and a corridor.

Building Areas	Total Area	Exterior Wall Area	Window Area	Roof Area
Residences	137,433	33,664	9945	12,167
First story retail/office	12,167	4519	1440	0
Total	146,000	38,183	11,385	12,167

The exterior walls are assumed to be composed of 8" concrete with a gypsum board finish. The roof is made up of built-up roofing, insulation (new vintage only) and a concrete deck.

Window maintenance (i.e. opening and closing shades) is utilized in the residences. Single-pane, clear glass is used for the all of the windows; most of the windows in the residences are operable, the windows in the first floor retail/offices are not operable. Seventeen percent of the exterior walls are windows throughout the building.

A two-pipe fan coil system utilizing an air-cooled reciprocating chiller serves the bottom half of the apartment building and packaged terminal air conditioners serve the top half. The hallways are unconditioned throughout the building.

Each residence has a 30 gallon gas water heater with a recovery rate of 21,000 BTU/hr.

BASE CASE PROTOTYPE SPECIFICATIONS APARTMENT

HVAC Systems	Dist Type	Area Desc	Area Size	Cooling Type
System 1	2-pipe fan coil	first 6 floors	73,000	Central Chiller
System 2	PTAC	top 6 floors	63,000	DX

HVAC Efficiencies/Controls	Vintage	
	Exs	New
System 1		
Cooling kW/ton	0.85	0.75
Cooling Tons	80	60
Economizer Type	none	temperature
Chilled Water Reset	no	yes
Chilled Water Pipe Gain (°F)	0.7	0.5
Chilled Water Valve Type	3-way	2-way
System 2		
Cooling COP	2.25	2.9
Cooling Size (BTU/sqft)	25	25
Economizer Type	none	temperature
Fan Control	const vol.	const vol.
Design Duct DT (°F)	n/a	n/a

Three cooling setpoints have been defined and are described below.

Setpoint	Zones/spaces	Clg setpoint
csp0	setup used in office/retail	95° F
csp1	lobby, office, retail	75° F
csp2	residences, occupied, day	75° F
csp3	residences, unoccupied, night	80° F
csp4	apartments, night	75° F

The apartment building has schedules for each of its major areas; separate schedules control occupancy, lighting, equipment and infiltration in each of the zones. It is assumed that 30 percent of the residences are occupied all day long and the remainder of the residences are unoccupied during workdays.

<u>Basic Schedules (modified hourly)</u>	
residences (home all day)	24 hrs
residences (away during day)	6p - 8a
lobby	24 hrs
office/retail	8a - 8p

Separate lighting densities and schedules are assigned by area usage, as are equipment (plug load) densities and schedules. These values, along with the exterior lighting and domestic hot water requirements are assigned to match the target EUI values from Energy 2020. The values for the new vintage represent the application of the new Hawaii energy code and/or expected performance relative to the existing vintage.

zone description	Lighting Watts/sqft	
	Existing	New
hallways	1.2	1.0
residences	0.96	0.8
lobby	0.67	1.32
office.	1.8	1.50
retail	2.8	2.1
Exterior Lighting	0.060	0.049

zone description	Equipment Watts/sqft	
	Existing	New
hallways	0.0	0.0
residences	1.05	1.05
lobby	0.0	0.0
office	1.1	1.1
retail	1.43	1.43

Refrigeration is not explicitly modeled in the residences; rather, it is included in the overall equipment loads.

Target EUI's by end-use are from ENERGY 2020 and HECO's COMMEND Forecasting Model. (See "Volume 2, The DSM Opportunity Report, Section 4" for more detail). The table and graphs below show the results of the baseline simulations for both the existing and new vintages as well as the target EUIs.

TARGET AND SIMULATED ANNUAL ENERGY CONSUMPTION BY END-USE APARTMENTS

kWh/ft2/yr	LIGHTS	EQUIP	COOLING	VENT	DHW	EXT-LTG
TARGET	3.55	3.01	5.51	0.73	1.77	0.28
EXISTING	2.96	3.02	6.79	0.57	1.69	0.28
NEW	2.42	3.02	5.76	0.45	1.30	0.28

The new vintage includes shell improvements, such as roof insulation and tinted glazing, reductions in lighting densities and HVAC equipment improvements, including improvements in the service hot water specifications.

Service hot water is modeled for both gas and electric fuel types; the table below shows the annual energy consumption for the various hot water models.

**SERVICE HOT WATER ENERGY USE BY VINTAGE AND FUEL TYPE
APARTMENTS**

VINTAGE	ELECTRIC kWh/ft2/yr	GAS therms/ft2/yr
NEW	1.30	0.10
EXISTING	1.69	0.17

4.0 REFERENCES

1. Barakat and Chamberlin, Inc. (February, 1994) "Characterization of Building Prototypes." Prepared for the Department of Business, Economic Development, and Tourism, State of Hawaii.
2. Eley Associates. (December, 1992) "Impact Analysis: Hawaii Model Energy Code." Prepared for the Energy Division, Department of Business, Economic Development, and Tourism, State of Hawaii.
3. Eley Associates. (July, 1993) "Hawaii Model Energy Code: Energy Efficiency Standard for Buildings." Prepared for the Energy Division, Department of Business, Economic Development, and Tourism, State of Hawaii.
4. NEOS Corporation. (March, 1994) "Technology Energy Savings, Volume II: Building Prototypes." Prepared for the California Conservation Inventory Group.
5. NEOS Corporation. (April, 1994) "Working Paper on Building Prototypes." Prepared for the Energy Division, Department of Business, Economic Development, and Tourism, State of Hawaii.
6. NEOS Corporation. (April, 1994) "Working Paper on Baseline UECs and EUIs and Initial Estimates of Building and Appliance Stocks." Prepared for the Energy Division, Department of Business, Economic Development, and Tourism, State of Hawaii.

APPENDIX A

COMMERCIAL BASELINE LIGHTING TECHNOLOGIES

Building Type: Large Office

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot 75W	PAR 100W	400W
Office	12527	6264	0	0	142	0	198	0
Retail	406	203	0	0	15	66	0	0
Kitchen	61	31	0	0	0	0	0	0
Dining	85	43	0	0	61	21	0	0

Number of Exit Signs: 330

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot/ Display 75W	PAR 100W	400W
Office	12469	6235	0	0	118	0	165	0
Retail	391	196	0	0	12	53	0	0
Kitchen	62	31	0	0	0	0	0	0
Dining	87	44	0	0	22	16	0	0

Number of Exit Signs: 330

Building Type: Small Office

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Office	360	180	0	0	0	0	0	0

Number of Exit Signs: 10

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Office	360	180	0	0	0	0	0	0

Number of Exit Signs: 10

Building Type: Large Retail

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot/ Display 75W	Spot 150W	400W
Sales	2063	1032	0	0	127	203	101	0
Office	59	30	0	0	0	0	0	0
Storage	176	88	0	0	0	0	0	0

Number of Exit Signs: 36

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot/ Display 75W	Spot 150W	400W
Sales	2016	1008	0	0	104	166	83	0
Office	60	30	0	0	0	0	0	0
Storage	175	88	0	0	0	0	0	0

Number of Exit Signs: 36

Building Type: Small Retail

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot/ Display 75W	100W	400W
Sales	48	24	0	0	6	14	0	0
Storage	6	3	0	0	0	0	0	0

Number of Exit Signs: 2

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot/ Display 75W	100W	400W
Sales	48	24	0	0	5	12	0	0
Storage	6	3	0	0	0	0	0	0

Number of Exit Signs: 2

Building Type: Fast Food Restaurant

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Entry	0	0	0	0	4	0	0	0
Kitchen	13	7	0	0	0	0	0	0
Restrooms	0	0	0	0	2	0	0	0
Dining	13	7	0	0	8	0	0	0

Number of Exit Signs: 5

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	40W	75W	100W	400W
Entry	3	13	0	0	0	0	0	0
Kitchen	13	7	0	0	0	0	0	0
Restrooms	2	2	0	0	0	0	0	0
Dining	13	7	0	0	6	0	0	0

Number of Exit Signs: 5

Building Type: Sit Down Restaurant

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Entry	0	0	0	0	5	0	0	0
Kitchen	24	12	0	0	0	0	0	0
Restrooms	0	0	0	0	4	0	0	0
Dining	0	0	0	0	36	0	0	0

Number of Exit Signs: 5

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	40W	100W	400W
Entry	0	0	0	0	5	0	0	0
Kitchen	23	12	0	0	0	0	0	0
Restrooms	4	2	0	0	0	0	0	0
Dining	0	0	0	0	0	41	0	0

Number of Exit Signs: 5

Building Type: Grocery Store

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Bakery	20	10	0	0	0	0	0	0
Office	16	8	0	0	0	0	0	0
Storage	0	0	46	23	0	0	0	0
Cashier	72	36	0	0	0	0	0	0
Sales	0	0	344	172	0	0	0	0

Number of Exit Signs: 12

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Bakery	20	10	0	0	0	0	0	0
Office	16	8	0	0	0	0	0	0
Storage	0	0	46	23	0	0	0	0
Cashier	72	36	0	0	0	0	0	0
Sales	0	0	342	171	0	0	0	0

Number of Exit Signs: 12

Building Type: Refrigerated Warehouse

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Office	32	16	0	0	0	0	0	0
Dock	0	0	64	32	0	0	0	0
Freezer	0	0	0	0	0	0	0	44
Meat/Deli	0	0	0	0	0	0	0	22
Produce	0	0	0	0	0	0	0	33

Number of Exit Signs: 25

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	250W
Office	32	16	0	0	0	0	0	0
Dock	0	0	64	32	0	0	0	0
Freezer	0	0	0	0	0	0	0	44
Meat/Deli	0	0	0	0	0	0	0	22
Produce	0	0	0	0	0	0	0	33

Number of Exit Signs: 25

Building Type: Non-Refrigerated Warehouse

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Office	228	114	0	0	0	0	0	0
Service	0	0	44	22	0	0	0	8
Storage	0	0	0	0	0	0	0	60

Number of Exit Signs: 15

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	250W
Office	228	114	0	0	0	0	0	0
Service	0	0	40	20	0	0	0	8
Storage	0	0	0	0	0	0	0	60

Number of Exit Signs: 15

Building Type: Hospital

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	250W
Kitchen	160	80	0	0	0	0	0	0
Emergency	456	228	0	0	0	0	0	12
Lab	850	425	0	0	0	0	0	0
Engineering	0	0	544	272	0	0	0	0
Offices	2040	1020	0	0	0	0	0	0
Wards	2000	1000	0	0	239	0	143	0
Nursing	2506	1253	0	0	0	0	0	0
Surgery	385	193	0	0	0	0	0	168

Number of Exit Signs: 258

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	250W
Kitchen	160	80	0	0	0	0	0	0
Emergency	474	237	0	0	0	0	0	10
Lab	854	427	0	0	0	0	0	0
Engineering	0	0	544	272	0	0	0	0
Offices	1760	880	0	0	0	0	0	0
Wards	2000	1000	0	0	210	0	54	0
Nursing	2566	1283	0	0	0	0	0	0
Surgery	236	0	0	0	0	0	0	164

Number of Exit Signs: 258

Building Type: School

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	250W
Gymnasium	0	0	0	0	0	0	0	4
Cafeteria	70	35	0	0	0	0	0	0
Kitchen	42	21	0	0	0	0	0	0
Offices	167	84	0	0	0	0	0	0
Classroom	1581	791	0	0	0	0	0	0

Number of Exit Signs: 50

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	250W
Gymnasium	0	0	0	0	0	0	0	4
Cafeteria	69	35	0	0	0	0	0	0
Kitchen	42	21	0	0	0	0	0	0
Offices	167	84	0	0	0	0	0	0
Classroom	1578	789	0	0	0	0	0	0

Number of Exit Signs: 50

Building Type: College

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	400W
Classroom	9850	4925	0	0	0	0	0	0
Cafeteria	230	115	0	0	0	0	0	0
Kitchen	98	49	0	0	0	0	0	0
Shop/Fac.	0	0	152	76	0	0	0	0
Dormitory	244	122	0	0	175	0	0	0

Number of Exit Signs: 300

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	75W	100W	250W
Classroom	9689	4845	0	0	0	0	0	0
Cafeteria	230	115	0	0	0	0	0	0
Kitchen	100	50	0	0	0	0	0	0
Shop/Fac.	0	0	152	76	0	0	0	0
Dormitory	240	120	0	0	144	0	0	0

Number of Exit Signs: 300

Building Type: Hotel

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			Spots 150W
	Lamps	Ballasts	Lamps	Ballasts	60W	Spots/ Display 75W	Spots/ Display 100W	
Corridor	444	222	0	0	0	0	286	0
Rooms	1166	583	0	0	7520	0	0	0
Lobby	90	45	0	0	0	0	0	103
Office	1500	750	0	0	0	0	0	0
Conference	540	270	0	0	0	0	0	232
Maintenance	0	0	136	68	0	0	0	0
Dining	0	0	0	0	251	0	0	100
Retail	300	150	0	0	0	172	0	0
Kitchen	350	175	0	0	0	0	0	0

Number of Exit Signs: 270

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID	Comp. Flour.
	Lamps	Ballasts	Lamps	Ballasts	60W	Spots 75W	Spots 100W	Spots 125W	15W
Corridor	442	221	0	0	0	0	239	125	0
Rooms	1194	597	0	0	2435	0	0	0	4870
Lobby	90	45	0	0	0	0	0	103	0
Office	1494	747	0	0	0	0	0	0	0
Conference	538	269	0	0	0	0	0	232	0
Maintenance	0	0	136	68	0	0	0	0	0
Dining	0	0	0	0	240	0	0	100	0
Retail	300	150	0	0	0	143	0	0	0
Kitchen	350	175	0	0	0	0	0	0	0

Number of Exit Signs: 270

Building Type: Resort

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot 75W	Spot 100W	Spot 150W
Corridor	463	232	0	0	0	0	199	0
Rooms	972	486	0	0	6271	0	0	0
Lobby	66	33	0	0	0	0	0	76
Office	274	137	0	0	0	0	0	0
Conference	494	247	0	0	0	0	0	142
Maintenance	0	0	109	55	0	0	0	0
Dining	0	0	0	0	252	0	0	101
Retail	220	110	0	0	0	126	0	0
Kitchen	512	256	0	0	0	0	0	0
Bar/Lounge	0	0	0	0	49	0	0	20

Number of Exit Signs: 215

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID	Comp. Fl.
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot 75W	Spot 100W	Spot 125W	15W
Corridor	461	231	0	0	0	0	166	0	0
Rooms	995	498	0	0	1692	0	0	0	4061
Lobby	66	33	0	0	0	0	0	76	0
Office	273	137	0	0	0	0	0	0	0
Conference	492	246	0	0	0	0	0	142	0
Maintenance	0	0	109	55	0	0	0	0	0
Dining	0	0	0	0	241	0	0	101	0
Retail	219	110	0	0	0	105	0	0	0
Kitchen	511	256	0	0	0	0	0	0	0
Bar/Lounge	0	0	0	0	46	0	0	20	0

Number of Exit Signs: 215

Building Type: Apartment

Vintage: Existing

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot 75W	100W	400W
Corridor	170	85	0	0	0	0	73	0
Residence	272	136	0	0	1752	0	0	0
Lobby	4	2	0	0	0	0	8	0
Office	298	149	0	0	24	0	0	0
Retail	120	60	0	0	0	68	0	0

Number of Exit Signs: 146

Vintage: New

Baseline Number of Lamps/Ballasts

Zone Name	4' Fluorescent		8' Fluorescent		Incand. Lamps			HID
	Lamps	Ballasts	Lamps	Ballasts	60W	Spot 75W	Spot 100W	400W
Corridor	170	85	0	0	0	0	61	0
Residence	270	135	0	0	1460	0	0	0
Lobby	4	2	0	0	0	0	6	0
Office	298	149	0	0	20	0	0	0
Retail	106	0	0	0	0	51	0	0

Number of Exit Signs: 608