STATE OF HAWAII FACILITIES ON OAHU ENERGY BENCHMARKING STUDY

VOLUME I
Report and Recommendations

Submitted to

The State of Hawaii

Department of Business, Economic Development, & Tourism
Strategic Industries Division

By

Cedric D. O. Chong and Associates
828 Fort St. Mall, Ste. 500
Honolulu, HI 96813

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THE DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
STATE OF HAWAII

Disclaimer

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Lane, Bill – State Account Representative, Hawaiian Electric Company, Inc., Honolulu, Hawaii

Raman, Elizabeth - Energy Conservation Program Specialist, Strategic Industries Division, Department of Business, Economic Development, & Tourism, Hawaii

Shon, Carolyn - Energy Branch Manager, Strategic Industries Division, Department of Business, Economic Development, & Tourism, Hawaii

Wayne Nakamura - Housing and Community Development Corporation of Hawaii

Hisano, James - Department of Accounting and General Service, Hawaii

Dean Shimamura - Department of Accounting and General Service, Hawaii

Wendy Cheuk - Department of Transportation, Hawaii

Roy Ikeda - Department of Education, Hawaii

Scuma Elliot - Department of Education, Hawaii

Prepared By:

Melek Yalcintas/ Joel Yuen, Cedric D. O. Chong and Associates, Honolulu, Hawaii

EXECUTIVE SUMMARY

This benchmarking study evaluates the electrical energy consumption and characterizes the distribution of electrical energy usage for the State of Hawaii facilities on Oahu by State agency, building occupancy type, and end use. Additionally, benchmarking for various Energy Conservation Measures (ECMs), including a projection of the cost for their implementation, and their associated energy savings potential, are presented in the report.

The benchmarking data for the study is based on several sources, including: 1) previously conducted energy audits on various State buildings on Oahu, 2) electricity billing history for the largest State facilities, 3) information on previously implemented ECMs identified through Hawaiian Electric Company's Demand Side Management (DSM) rebate history, 4) building occupied square footage area information provided by DAGS for certain State facilities on Oahu from 2001 records, 5) completed energy survey forms from several State agencies, and 6) an energy benchmarking study for the UH Manoa Campus conducted in 2004.

Based on the results of this study, there are approximately 2,625 buildings that are identified as being owned and operated by the State of Hawaii. Approximately 80 % of those buildings are located on Oahu. The total building floor space of the State of Hawaii facilities on Oahu, excluding pavements, sidewalks, courtyards and any open spaces, is estimated at about 26,367,927 square feet. The total yearly electrical energy consumption for all State facilities on Oahu for 2004 was 557,654,688 kWh. This amounted to a total cost of $71,372,318 for electricity in 2004, at an average rate of $0.128 per kWh. This electrical energy consumption corresponded to an average of 21.1 kWh per square feet of occupied building space per year in electrical energy consumption, and an average of $2.70 per square foot per year in electricity costs, for the Oahu facilities in 2004. The costs reflect the total cost for electricity, and include the costs for the demand charges, energy charges, fuel oil adjustment, and additional customer service charges and discounts that will vary somewhat from account to account depending on the actual rate schedules and service agreements. Other sources of energy

used by the State facilities on Oahu, such as gas and fuel oil, are not evaluated in this report.

The distribution of building floor area and electrical energy usage by State agency is illustrated in charts in Figure ES-1 and Figure ES-2. As can be followed from the charts, UH Manoa Campus, DOE K-12 schools and DOT are the highest energy consumers that also occupy the most floor area. The building floor area and yearly electricity usage per square foot for each agency and State-wide percentage of electricity usage are documented in Table ES-1. This table is ordered from the largest to the smallest in terms of occupied area and electrical consumption.

Electrical energy usage distribution by utilization category, including air conditioning, lighting and miscellaneous equipment for all facilities on Oahu is illustrated in Figure ES-3. Air conditioning is the highest electrical energy consuming category at 44%, followed by lighting at 30%.

Electrical energy usage distribution by occupancy type, including educational classroom/office, hospital, airport, office, highways and harbors, and correction facilities, for Oahu are illustrated in Figure ES-4. This figure shows that approximately 50% of State facilities are educational classroom/office type facilities, including the DOE's schools, the community colleges, and the University of Hawaii at Manoa. The other major occupancies are general office (17.7%) and airport terminals (17.6%)

Additional useful information for State facilities on Oahu is the comparison of the total electrical usage and cost comparison over the past few years. Figure ES-5 and Figure ES-6 show the electrical consumption and electrical cost trends for the period from 2002 through 2004. While the annual electrical energy consumption also increased during this period, the increase in the cost of electricity has been more significant due to the escalation in the fuel oil adjustment charges. If the fuel oil adjustment charges continue to escalate, the State's electrical costs will increase further, even if the State's electricity usage remains steady. This Figure emphasizes the importance of energy conservation in State facilities.

ECMs documented in the reference sources, integrated with additional engineering assumptions, were extrapolated for all of the State facilities on Oahu where applicable. The ECMs were then categorized by their energy savings potential and payback period. As shown in Table ES-2, a total of eleven ECMs were identified that would produce energy savings with a payback period of less than 15 years if they were implemented. These identified ECMs are: 1) interior and exterior lighting replacements with less energy consuming lighting, 2) replacement of existing 'Exit' signs with efficient LED 'Exit' signs, 3) reflective solar window tinting, 4) chiller retrofits, 5) VFD (Variable Frequency Drive) replacement, 6) high efficiency motor replacement, 7) installation of waste heat recovery systems, 8) packaged air conditioning unit replacement, 9) facility management system installation, 10) roof insulation installation, 11) other (including ECMs to convert constant volume air conditioning systems to VAV (Variable Air Volume) systems, to repair VAV control system, and to install carbon dioxide sensors).

Based on our analysis, implementation of these Energy Conservation Measures (ECMs) for all State buildings on Oahu will result in an estimated electrical savings of 78,906,487 kWh per year, or $10,735,823 per year. The estimated construction cost for implementation of the evaluated ECMs is $78,256,206, which would result in a payback of about 7.3 years. Implementation of these ECMs will result in roughly a 14% reduction in the electrical consumption of the State facilities on Oahu. These ECMs and the percentage of energy savings that are projected to be realized from their implementation are listed in Table ES-2. Please note that any further increases in electrical costs due to further fuel oil adjustments are not included in the ECM payback projections. If these future increases in electrical costs are included in the ECM payback estimates, the payback period will be reduced proportionately. Table ES-3 shows the same ECMs listed in Table ES-2 ordered by energy savings potential from highest to lowest, including the percentage of electrical energy saving potential. According to our analysis, ECM-IV Chiller Retrofits has the highest electrical energy savings potential of 3.7%, followed by ECM-I Interior and Exterior Lighting Replacement with a 3.1% savings potential, ECM-IX Facility Management Systems (FMS) Installation with a 2.1% savings potential and ECM-V Variable Drive Utilization with a 2.0% savings potential.

Performance contracting is one possible means to enable the State to implement the identified ECMs in this study. Should performance contracting be utilized, we recommend that the performance contracting be pursued for each State agency separately. All ECMs should be incorporated into the performance contract for each agency as a single package to achieve maximum energy savings benefits. Based on this benchmarking analysis, the combined simple payback period for the implementation of all ECMs at each agency is less than 10 years. This suggests that each agency's facilities are acceptable candidates for performance contracting, since the energy cost savings realized over the life of the contract will cover the costs for the ECM improvements. The priority for performance contracting should be given to the agencies with lower payback periods. Table ES-4 lists the State agencies recommended for performance contracting with the priority ordered from lowest simple payback period to the highest. In the list, some of DAGS, DBEDT, DOD, and JUDICIARY facilities have already implemented selected ECMs using performance contracting. The Table ES-4 has already factored the previous implemented ECM savings into the analysis, and includes the additional projected savings and cost savings for only the facilities that have not used performance contracting and ECMs that have not yet been implemented.

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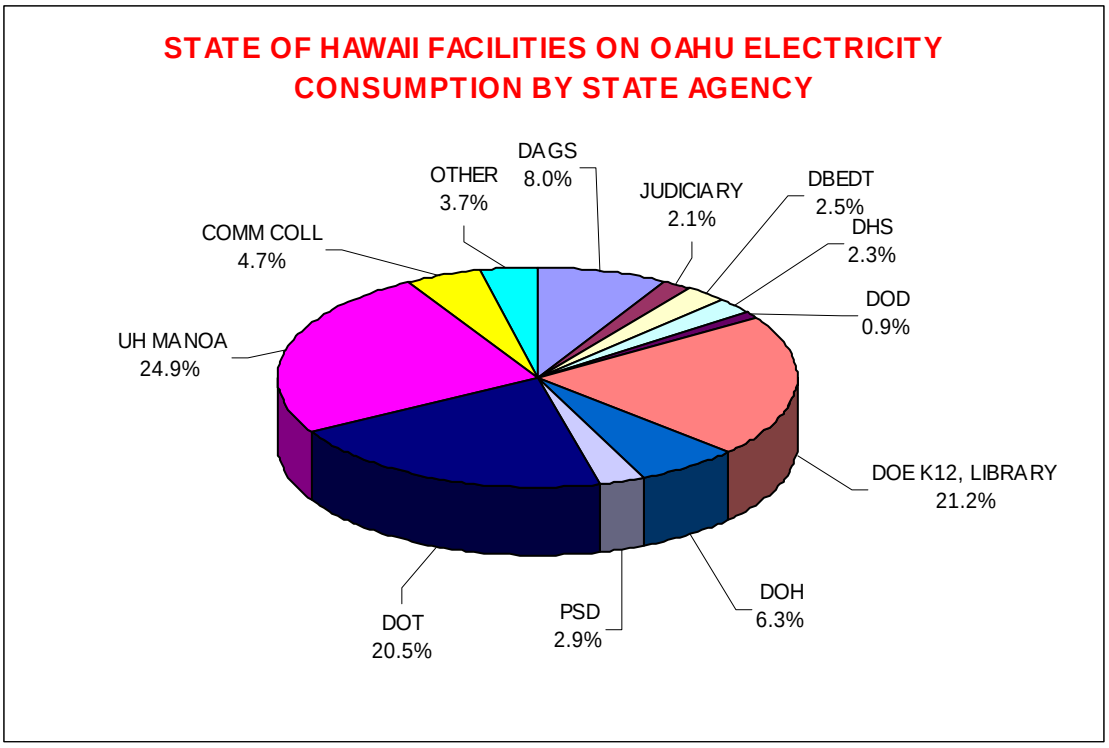

Figure ES-1: State of Hawaii Facilities on Oahu Building Electricity Consumption by State Agency.

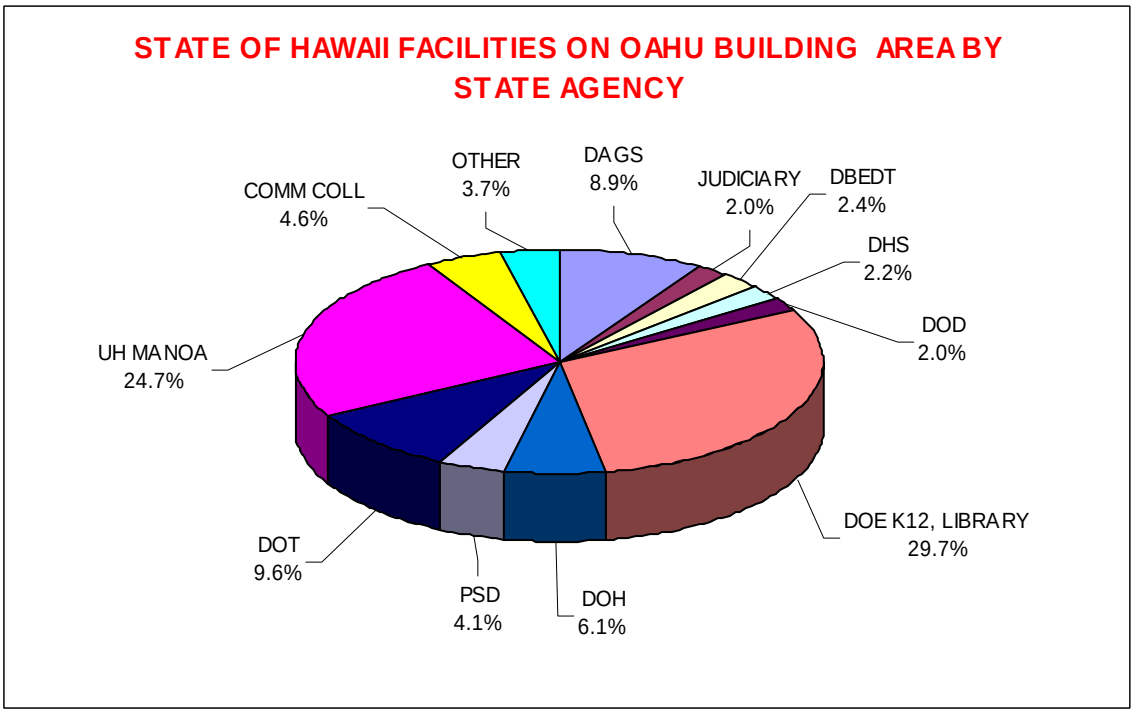

Figure ES-2: State of Hawaii Facilities on Oahu Building Square Feet Area by State Agency.

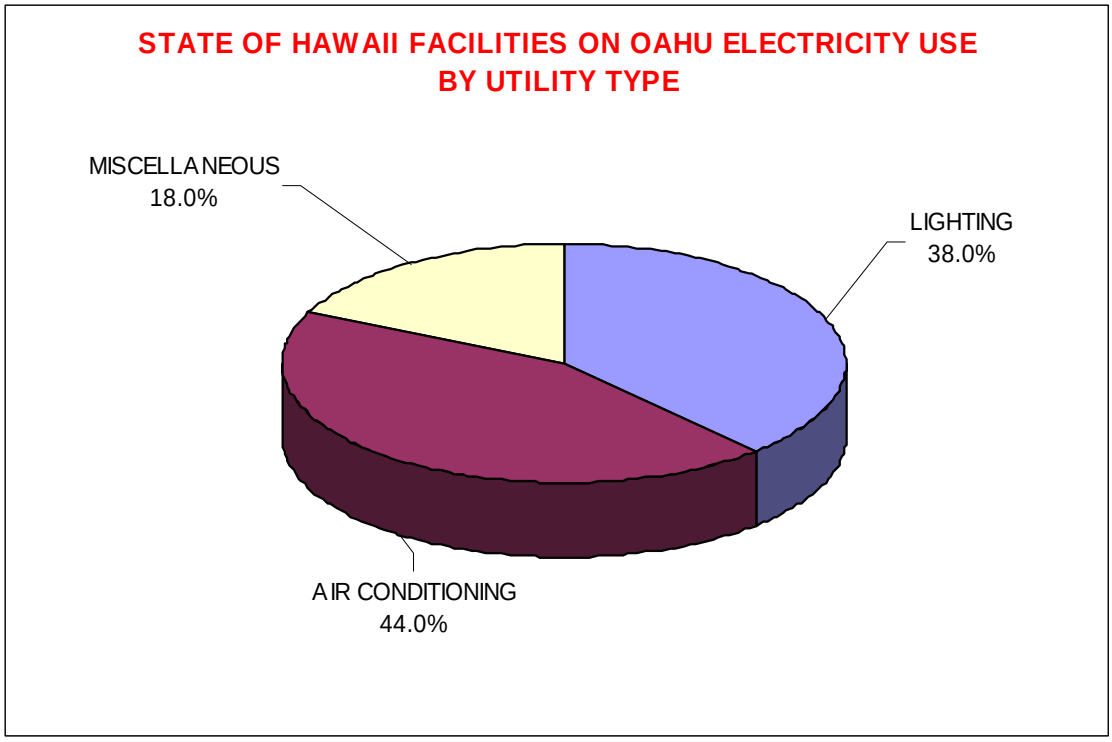

Figure ES-3: State Facilities on Oahu Electricity Consumption Percentage by Utility.

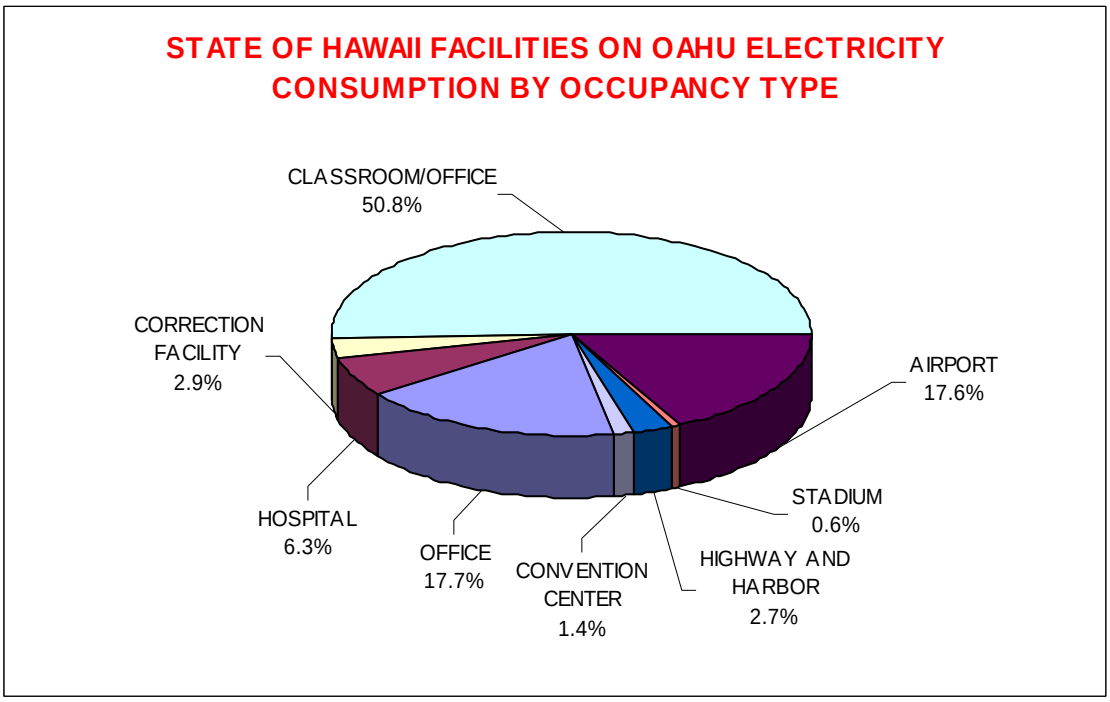

Figure ES-4: State Facilities on Oahu Electricity Consumption Percentage by Building Occupancy.

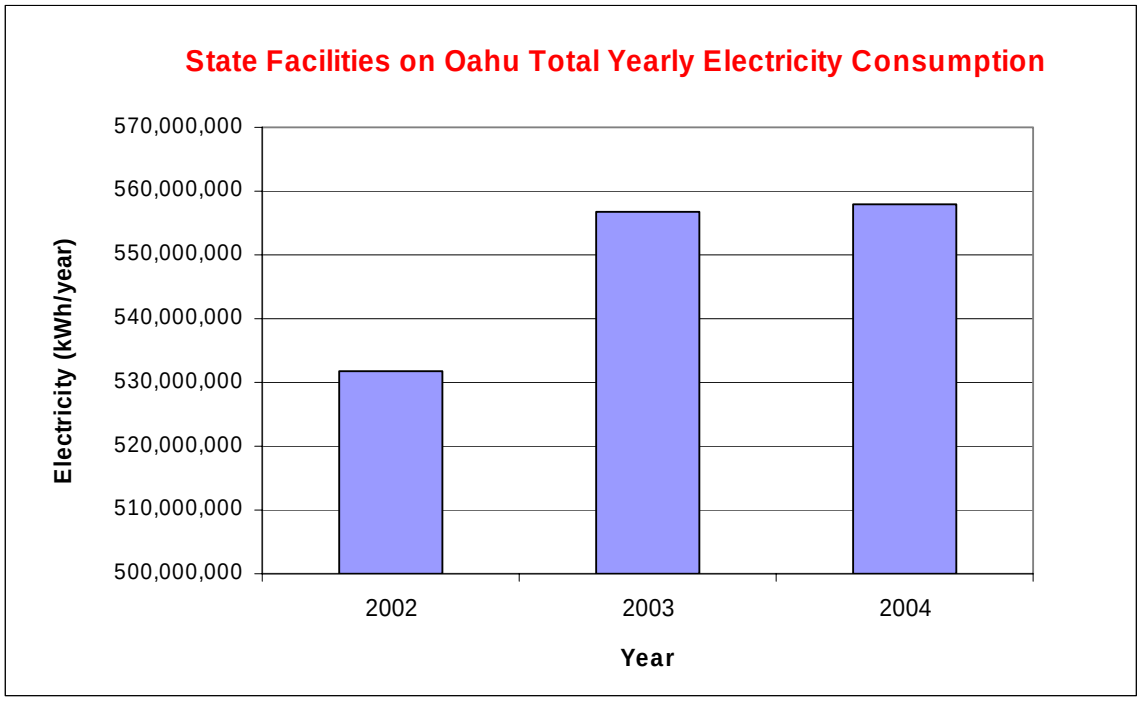

Figure ES-5: State Facilities on Oahu Electricity Consumption Trend in the past three years.

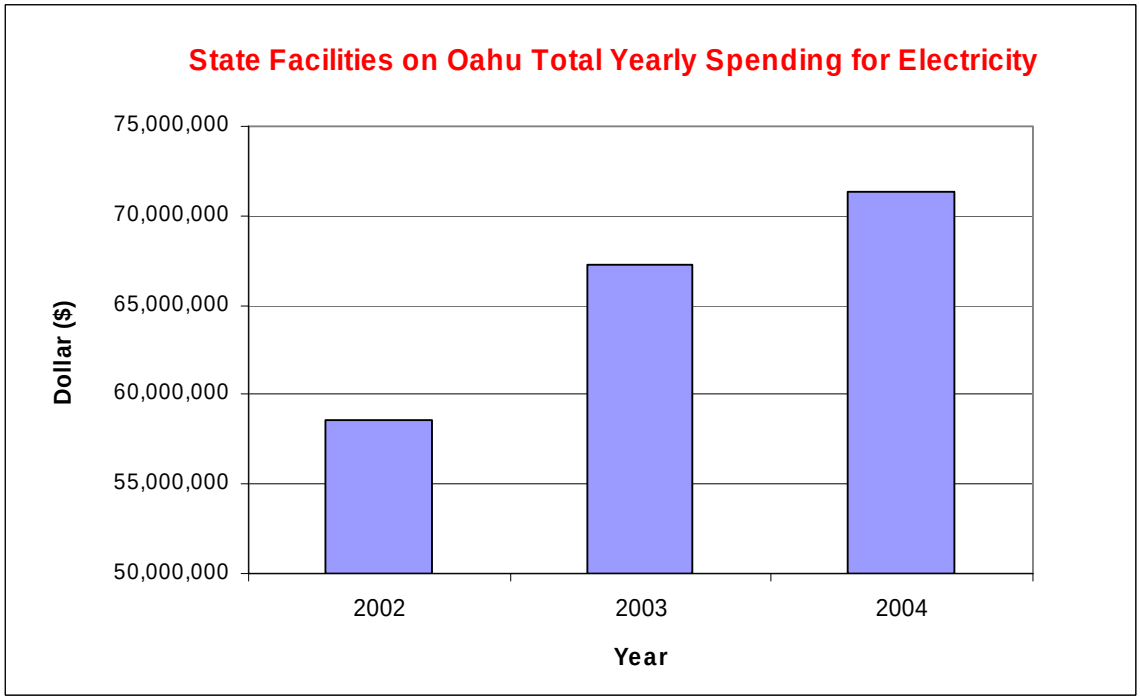

Figure ES-6: State Facilities on Oahu Electricity Cost Trend in the past three years.

Table ES-1: State of Hawaii Facilities on Oahu Building Floor Area and Yearly Electrical Energy Use as of 2004

State Agency	Total Occupied Building Space (sq.ft.)	% Total Building Space (sq.ft.)	Total Building Electricity (kWh/year)	Total Building Electricity Use per square foot (kWh/sq.ft.-year)	% of Total Energy Use	% Energy Use per % Building Area
UH MANOA	6,509,109	24.7	138,877,571	21.3	24.9	1.0
DOE K12, PUBLIC LIBRARY	7,829,650	29.7	118,266,875	15.1	21.2	0.7
DOT	2,540,917	9.6	114,437,730	45.0	20.5	2.1
DAGS	2,337,265	8.9	44,505,800	19.0	8.0	0.9
DOH	1,606,870	6.1	35,116,171	21.9	6.3	1.0
COMM COLL	1,220,733	4.6	26,045,410	21.3	4.7	1.0
PSD	1,087,733	4.1	16,316,000	15.0	2.9	0.7
OTHER*	971,907	3.7	20,530,537	21.1	3.7	1.0
DBEDT	620,043	2.4	13,805,340	22.3	2.5	1.1
DHS	578,056	2.2	12,870,502	22.3	2.3	1.1
JUDICIARY	536,839	2.0	11,952,797	22.3	2.1	1.1
DOD	528,803	2.0	4,929,956	9.3	0.9	0.5
TOTAL	26,367,927	100	557,654,688	21.1	100	

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture

Table ES-2: Energy Conservation Measures and Potential Energy Savings as of 2004

Description		Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($/year)	Estimated Construction Cost ($)	Simple Payback (Year)
ECM-I	Interior and exterior lighting Replacement	17,048,460	3.1	2,439,780	16,522,333	6.8
ECM-II	LED Exit Sign Installation	1,450,236	0.3	553,726	2,241,274	4.0
ECM-III	Reflective Solar Window Tinting	3,665,623	0.7	474,623	2,900,472	6.1
ECM-IV	Chiller Retrofits	20,590,260	3.7	2,630,636	35,157,100	13.4
ECM-V	Variable Speed Drive Utilization	11,300,314	2.0	1,451,133	6,777,101	4.7
ECM-VI	Motor Replacement with High Efficiency Motors	2,396,361	0.4	301,764	2,094,597	6.9
ECM-VII	Waste Heat Recovery System	944,912	0.2	121,538	273,887	2.3
ECM-VIII	Packaged Air Conditioning Unit Replacement	1,253,157	0.2	159,300	1,338,116	8.4
ECM-IX	Facility Management Systems (FMS) Installation	11,443,680	2.1	1,476,604	1,766,651	1.2
ECM-X	Insulation Installation	5,415,477	1.0	685,556	5,062,642	7.4
ECM-XI	Other	3,398,489	0.6	441,154	4,122,034	9.3
	Totals	78,906,487	14.2	10,735,823	78,256,206	7.3

Table ES-3: Energy Conservation Measures and Potential Energy Savings as of 2004, Sorted by Energy Savings Impact

Description		Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($/year)	Estimated Construction Cost ($)	Simple Payback (year)
ECM-IV	Chiller Retrofits	20,590,260	3.7	2,630,636	35,157,100	13.4
ECM-I	Interior and exterior lighting Replacement	17,048,460	3.1	2,439,780	16,522,333	6.8
ECM-IX	Facility Management Systems (FMS) Installation	11,443,680	2.1	1,476,604	1,766,651	1.2
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ECM-VII	Waste Heat Recovery System	944,912	0.2	121,538	273,887	2.3
	Totals	78,906,487	14.2	10,735,823	78,256,206	7.3

Table ES-4: List of State Agencies That are Candidates for Performance Contracting

Building Occupancy	Simple Payback (Year)	Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($)	Estimated Construction Cost ($)
DBEDT	5.1	1,153,667	0.2	160,331	823,276
DOE K12, PUBLIC LIBRARY	5.2	11,895,402	2.1	1,690,408	8,751,558
OTHER*	5.3	2,742,918	0.5	379,141	2,015,736
DAGS	5.5	8,195,882	1.5	1,117,324	8,482,092
PSD	5.6	2,213,972	0.4	314,355	1,761,040
JUDICIARY	5.9	831,839	0.2	113,905	672,767
DOD	6.4	1,745,860	0.3	238,626	1,521,358
DOH	7.3	5,787,111	1.0	780,453	5,711,629
DHS	7.4	2,218,352	0.4	300,422	2,182,610
UH MANOA	8.2	28,952,157	5.2	3,891,630	31,906,080
COMM COLL	8.2	3,779,793	0.7	501,856	4,107,137
DOT	8.3	9,389,534	1.7	1,247,371	10,320,922
TOTAL	7.3	78,906,487	14.2	10,735,823	78,256,206

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION/PURPOSE

The purpose of this benchmarking study is to evaluate the electrical energy usage of the State of Hawaii Facilities on the Island of Oahu and to identify possible Energy Conservation Measures (ECMs), along with their estimated savings and estimated construction costs that could be implemented to reduce electrical costs.

The specific scope of work for this project includes the following:

A. Data Collection Phase:

1. Obtain and review previous reports, energy audits, and spreadsheets prepared under the State of Hawaii Energy Analysis Project, Phase I and II. Identify which buildings were audited/ surveyed, and summarize the results of the analysis for each audited/surveyed building; including total energy consumption, square footage, end-use energy, and energy savings, costs and payback for each Energy Conservation Measure (ECM) identified.

2. Verify and/or obtain electrical consumption data from Hawaiian Electric Company, Inc. (HECO) on all HECO installed and other meters for the State facility buildings on Oahu. Determine the total State facility energy usage and load profiles for major accounts, and for each building that has been metered.

3. Prepare a letter to solicit support and assistance from the various State agencies to collect information on the various facilities on the Island of Oahu.

4. Meet with representatives from each agency to collect the following information to support the benchmarking analysis:

(a) An inventory listing of each agency's buildings, along with a description of their operating schedule, occupancy, use, and floor area;

(b) A survey and copy of any reports for previously conducted energy studies, audits, or pre-final contracting proposals previously (within the last three years) conducted for their facilities;

(c) A listing of any other recent (within the last three years) upgrades or recommendations to their facilities; and

(d) A list of any known proposed (within the next three years) upgrades.

B Analysis Phase:

1. Develop a spreadsheet for all buildings that were previously audited/surveyed and metered that summarizes the energy consumption, square footage, electric EUI operating costs, and the energy savings, costs, and payback for each previously developed ECM. The deliverables may be found in Section 3.0 Benchmarking Data, Appendix 1.0 UH Manoa Campus Energy Benchmarking Study Executive Summary, and Appendix 3.0 Summary of Existing Energy Audit/Survey Results Presented in "Task 1-a-1 Report".

2. Extrapolate the data for previously metered and audited/surveyed buildings to the remaining State facilities on Oahu using engineering judgment and the information collected during Task A Data Collection (by the State or their State facility inventory). Only the State agencies that have cooperated and provided the requested information will be included in the analysis. Develop a separate spreadsheet for these buildings, including projected information on the energy consumption, square footage, EUI, and energy savings, cost and single payback for possible ECMs. The deliverables may be found in Section 4.0 Benchmarking Energy Analysis, Appendix 8.0 Baseline Benchmark

Analysis Electricity Use and Appendix 9.0 Baseline Benchmark Analysis by End Use Electricity.

3. Develop spreadsheets, which organize the buildings by agency, EUIs, age, square footage, operating costs, energy savings potential, ECM costs and payback. Summarize the current energy consumption levels of each building, and identify and prioritize the buildings that have the largest potential for energy savings. The deliverables may be found in Section 5.0 Benchmarking Energy Conservation Measures and Appendix 10.0 Energy Conservation Measure Benchmark Analysis.

4. Develop a spreadsheet which lists potential candidates for energy performance contracting. The deliverables may be found in Section 6.0 Recommendations and Conclusions.

C Report/Presentation Phase:

1. Three (3) copies of a Pre-final technical report that summarizes the results of the study, including an executive summary, introduction, body, spreadsheets, EUI results, implementation plan, summary, and appendices.

2. Prepare a power point presentation to present the findings and recommendations of the Executive Summary document to the STATE and provide an electronic copy of the same to the STATE.

3. Five (5) copies of final report on reproducible bond as well as an electronic copy in MS word and/or Excel as appropriate.

2.0 BACKGROUND

The total building occupied space for all State of Hawaii facilities on the island of Oahu, excluding external spaces such as sidewalks, courtyards, lanais etc. is estimated at 26,370,362 square feet. The total building square footage by State Agency is listed in Table 1. The main State agencies with large building floor areas are the Department of Accounting and General Service (DAGS), the Department of Business, Economic Development and Tourism (DBEDT), the Department of Education (DOE), the Department of Judiciary (JUDUCUARY), the Department of Defense (DOD), the Department of Health (DOH), the Department of Transportation (DOT), the Department of Human Service (DHS), Housing and Community Development Corporation of Hawaii (HCDCH) under the DHS, and the Department of Public Safety (PSD). The other departments with relatively less occupied space include the Department of Attorney General, the Department of Labor and Industrial Relations, the Department of Land and Natural Resources, the Department of Hawaiian Homelands, and the Department of Agriculture. A majority of the buildings were constructed between 1940 and 1960. Detailed information on the year of construction for most buildings was not available during this study period.

The main building type category for State of Hawaii facilities on Oahu is mixed use educational office/classroom type buildings. These buildings are primarily used by DOE. Following the educational office/classroom type facilities in size are general office type buildings operated by DAGS, airport, highway and harbor facilities operated by DOT. Hospitals, correction facilities and libraries, by DOH, PSD and DOE respectively, make up the smallest percentage of State facilities.

Most of the State buildings are of concrete construction. Temporary buildings in the university and community college campuses and in the schools are primarily modular office and portable classroom buildings that are of wooden construction. Building exterior wall insulation in the majority of the permanent buildings is in

good standing. There have not been any HECO rebates issued for any of the State of Hawaii facilities on Oahu for window tinting. An earlier benchmarking study conducted for the UH at Manoa Campus, a state facility with over six million square feet occupied building area, has also indicated that the windows for most of the buildings on campus were not retrofitted with reflective solar films.

The rebate records provided by HECO for the time period between 1997 and 2004 indicate that lighting retrofits for conversion from T-12 fluorescent lighting with magnetic ballasts to energy saving T-8 fluorescent lighting with electronic ballasts were implemented in some of the facilities. According to HECO's records, partial lighting retrofits were implemented primarily in DOE buildings, with a few installations also accomplished for DAGS, DOT, UH Campus and UH Community Colleges buildings.

The majority of large State office type buildings, airport, hospitals, public libraries, and the Judiciary buildings have central air conditioning. The DOE's K-12 classroom buildings generally do not have air conditioning. Many small portable classroom buildings and some of the DOE K-12 school offices are equipped with window air-conditioning or small DX split air-conditioning systems. Rebate records provided by HECO show rebates for central air conditioning and DX split air-conditioning systems, mainly for DAGS, DBEDT, DOE and UH buildings. HECO does not provide rebates for window air conditioning units.

Table 1: State of Hawaii Facilities on Oahu Building Floor Area as of 2004

State Agency	Total Occupied Building Space (sq.ft.)	% Total Building Space (sq.ft.)
UH MANOA	6,509,109	24.7
DOE K12, PUBLIC LIBRARY	7,829,650	29.7
DOT	2,540,917	9.6
DAGS	2,337,265	8.9
DOH	1,606,870	6.1
COMM COLL	1,220,733	4.6
PSD	1,087,733	4.1
OTHER	971,907	3.7
DBEDT	620,043	2.4
DHS	578,056	2.2
JUDICIARY	536,839	2.0
DOD	528,803	2.0
TOTAL	26,367,927	100

3.0 BENCHMARKING DATA

Benchmarking data for State of Hawaii Facilities on Oahu used to develop this study were based on the following sources:

1- An energy benchmarking study conducted for the University of Hawaii at Manoa Campus in 2004. The UH Manoa Campus contributes approximately 25% of State electricity consumption on Oahu.

2- Electrical billing history for 2003 and 2004 for the 76 largest State buildings on Oahu, provided by HECO. Rebate history for all State facilities on Oahu from 1997 through 2004 provided by HECO.

3- Energy survey results from the following reports: a) an energy survey walkthrough for four DAGS facilities; b) a detailed energy audit report on DBEDT Foreign Trade Zone Office and Warehouse Building; c) a lighting energy audit report on three Judiciary buildings on Oahu; and d) an Energy Conservation Measure (ECM) evaluation for 12 Department of Defense Hawaii Army National Guard (DOD HIARNG) Buildings.

4- A draft two-phase report entitled “Hawaii State Facility Energy Upgrade Analysis and Performance Contracting Potential Phase I and Phase II Reports”, prepared by Washington State Department of General Administration, Division of Engineering and Architectural Services, and submitted to DBEDT, Strategic Industries Division.

5- State facilities on Oahu, building square footage data provided by DAGS based on a 2001 survey. This data was marked incomplete, but did cover most of the DAGS, DOH, DOD, DOT, Judiciary, Agriculture, Public Libraries, and DNLR facilities here on Oahu.

6- Energy survey forms, developed as part of this benchmarking project, to collect general information on the building structure, operation, occupancy, and specific information on lighting and air conditioning equipment and conditions. However, only partial completed survey forms from the DAGS

and DOT were received during this benchmarking analysis and report development.

3.1 UH Manoa Energy Benchmarking Study

The electrical consumption of the UH Manoa campus comprises approximately 25% of the total electricity consumption by the State of Hawaii Facilities on Oahu. Likewise, approximately 24% of the occupied building square footage belongs to the UH Manoa campus. Therefore, the recently prepared UH Manoa Energy Benchmarking Study provides valuable data that was utilized to assist in the benchmarking analysis for this study. The UH Manoa energy benchmarking study is summarized as follows:

For the UH Manoa benchmarking study, a database was developed based on the campus electricity utility history, organized by the campus building occupancy type and building age. The developed database was evaluated against the building classification in order to identify the benchmarking trends. In the study, an Energy Utilization Index (EUI) was used to determine the relative energy usage of a given facility. EUI is defined as the ratio of a building's total energy usage for a year over the building's total square footage area:

EUI = kWh per year / sq.ft.

According to this study, the buildings on campus consumed an average of 22.8 kWh per year per square foot of occupied space in 2003, (EUI-22.8 kWh/sq.ft./year). However, large variations existed between the Energy Utilization Index (EUI) of buildings when evaluated by occupancy type (EUI ranges between 5.1 and 64.3 kWh/sq.ft.-year) and by building age (EUI ranges between 15.3 and 37.0 kWh/sq.ft.-year). Additionally, a detailed benchmarking analysis was conducted to identify the Energy Conservation Measures (ECMs) that were applicable to the majority of the campus buildings. Reports from earlier

energy audits for a total of 44 buildings, representing approximately 40% of the campus buildings square footage area, were evaluated. Campus walkthrough surveys were conducted for the buildings that had no prior energy audits. ECMs documented in the audit reports, integrated with additional engineering assumptions, were generalized for the entire campus when applicable. The ECMs were categorized by the**ir** energy savings potentials and payback periods. Three ECMs were identified that were applicable to the majority of the buildings through the campus. These ECMs are: 1) interior and exterior lighting replacements with efficient lighting, 2) replacement of existing exit signs with efficient LED exit signs, and 3), reflective solar window tinting. When extrapolated for the entire campus, it was determined that implementing these ECMs would reduce the UH Manoa Campus' electrical consumption by approximately 4.3 %. Eleven other ECMs were identified that were common to a sizable number of the buildings in the campus. When the savings for these ECMs were extrapolated for the entire campus, it was estimated that implementing these additional ECMs would reduce the campus electricity by another 11 percent, with payback periods ranging from 3 to 13 years. Several other ECMs were found to be applicable only to specific buildings in the campus. Therefore, they were not included in the generalized benchmarking analysis. Based on the benchmarking analysis, it was determined that the campus would be able to save up to approximately 20% in its current electrical use if all of the evaluated ECMs were applied throughout the campus. However, further detailed design and engineering analysis was recommended for a more precise estimate. The executive summary of the UH Manoa Benchmarking Study is included in Appendix 1.0.

The ECM analysis developed for the current State benchmarking report was mainly based on the extrapolation of the ECM's considered in the UH Manoa benchmarking study. Additional information used in the State Facilities ECM estimates were obtained from the HECO provided rebate history from 1997 throughout 2004, which is discussed in the next section.

3.2 Electrical Billing History for Large State Facilities on Oahu and Rebate History from 1997 through 2004

The electrical billing history for all large State Facilities that consume at least 1,000,000 kWh per year consists of a total of 76 meters. Based on the information provided by Hawaiian Electric (HECO), these 76 meters consumed approximately 396,611,900 kWh per year and accounted for 71 % of the State Facilities electricity usage on Oahu in 2004. The remaining 29 % of the electricity consumption was utilized by the medium size and small size facilities. The total electrical consumption of all State facilities on Oahu was 557,654,688 kWh in 2004, which amounted to a total electrical energy cost of $ 71,372,318.

In most cases, a single electrical meter measures electricity consumption from one single building or a group of buildings. For example the entire UH Manoa Campus electricity is measured by several meters with one meter accounting for more than 90 % of the campus electricity usage. On the other hand, in some cases, although a facility may be small, it may have several electricity meters.

The HECO electrical billing history for large State facilities on Oahu with 1,000,000 kWh per year or higher consumption for calendar year 2003 and 2004 are listed in Appendix 2.0.

Additionally, HECO has also provided rebate histories from 1997 through 2004 for all State Facilities on Oahu. A copy of the rebate histories sorted by State Departments and by rebate type is shown in Appendix 2.1. It is worthwhile to mention here how HECO rebates are issued and documented: HECO awards rebates under two main categories: prescriptive rebates and customized rebates. The prescriptive rebates in Appendix 2.1 include lighting rebates, motor rebates and space cooling rebates. Lighting rebates are usually for the replacement of T-12 fluorescent lights with magnetic ballasts with less energy consuming T-8 fluorescent lights with electronic ballasts. Motor rebates include any existing

standard motor replacement with premium efficiency motors. The premium motor efficiency requirements by motor size is specified by HECO. Space cooling rebates include replacement of DX type split air conditioning equipment, and packaged rooftop air conditioners with high efficiency units. Additional chiller plant improvements are not included in the space cooling category. Instead they are evaluated under the customized rebate category. The customized rebate is calculated by energy savings due to any type of equipment replacement in a building that is not covered by a prescriptive rebate. In some cases, a prescriptive rebate element may be included as a customized rebate if more than one equipment replacement has taken place at a time and the majority of the rebates are considered as customized. However, most of the time, as reflected in this study, the customized rebate format is used for chiller variable frequency drive (VFD) retrofits, conversion to DDC controls, or any other air-conditioning related equipment retrofits that do not qualify under the prescriptive rebate program.

As can be followed from the above summary, except lighting, most of the equipment retrofits in a building are related to the building's air conditioning system. Therefore, in the ECM benchmarking analysis presented in Section 5, all HECO rebates in Appendix 2.1 except lighting were categorized under air conditioning retrofits. This caused a slight error in the ECM evaluation, since it was possible that sometimes a customized rebate would include lighting retrofits as well. However, since it was not possible to quantify the content of a customized rebate, and it was less likely that energy savings in a customized rebate was dominated by savings from lighting retrofits, it was concluded that the slight error was tolerable.

3.3 Existing Energy Audit/Survey Results

A walkthrough energy survey was previously conducted on four DAGS buildings, namely Kinau Hale, Queen Liliuokalani, Kekuanaoa, and Keelikolani & Auhau,

as part of the "State Facility Energy Upgrade Analysis and Performance Contracting Potential Phase II Report." A detailed energy audit report was also previously developed for one DBEDT building, Foreign Trade Zone. A lighting energy audit report was previously prepared on five SOH Judiciary buildings Statewide, three being on Oahu. An Energy Conservation Measure (ECM) summary for 16 Department of Defense Hawaii Army National Guard (DOD HIARNG) Buildings Statewide, 12 being on Oahu, was also available for use in this benchmarking study.

As part of this study, a "Task 1-a-1" report was developed that summarized the "Existing Energy Audit/Survey Results." The information in the task report included data on the surveyed buildings' total square footage, yearly electricity consumption, typical building usage, operation schedule, building-renovation equipment retrofit history, and potential Energy Conservation Measures (ECM). Surveyed building indoor air quality related findings and future scheduled improvements (if any) were also included in the report. Additionally, reviews from earlier conducted Energy Performance Contract evaluations were included in the report to provide insight into potential benchmarking ECMs. Appendix 3.0 provides a copy of the "Task 1-a-1" report.

3.4 Hawaii State Facility Energy Upgrade Analysis and Performance Contracting Potential Phase I and Phase II Reports

This study which was completed in April 2004, covered all State facilities in Hawaii. The energy data was based on the Fiscal Year 2002 electricity billing history obtained from the utility companies in Hawaii; including Hawaiian Electric Company (HECO) on Oahu, Maui Electric Company (MECO) on Maui, Hawaii Electric and Lighting Company (HELCO) on Big Island and Kauai Island Utility Company (KIUC) on Kauai. Appendix 4.0 lists a summary of the State of Hawaii electrical consumption by State Agencies and percentage electricity consumed.

In the study approximately 2,625 buildings were identified as being owned and operated by the State of Hawaii. Out of the 2,625 buildings, 108 were classified as large size buildings that consumed 1,000,000 kWh or more electricity in a year. These buildings accounted for over 75 % of the electricity used by all of the State facilities. 152 buildings were classified as medium size buildings that consumed less than 1,000,000 kWh per year electricity but paid more than $50,000 per year for the electricity used. These medium size State facilities accounted for approximately 10 % of the electricity used by the State. The remaining buildings with yearly electricity bills less than or equal to $50,000 were classified as small size buildings. These 2325 buildings accounted for 15% of the State electricity consumption in 2004.

The electrical billings history for 2002 covering all large and medium size buildings on Oahu and the rebate history covering the time period from 1997 through 2003 were extracted from the referenced report and are presented in Appendix 4.1.

The building classification by large, medium and small size buildings based on their electricity consumption in the referenced study was also used in the current study. However, the main difference was that the current study was developed for the State facilities on Oahu only. Also, some of the buildings that consumed about 1,000,000 kWh per year in 2002 have consumed less in 2004 records. Therefore they were removed from the original large State facilities for Oahu list. Section 4 “Benchmarking Energy Analysis” provides more detailed information on the grouping of the State facilities on Oahu, and the methodology for the data processing for the benchmarking study.

3.5. State Facilities on Oahu Building Area Square Footage Data

The data for building area was provided by DBEDT from their historical records. They were originally collected by DAGS in 2001. This data was marked incomplete, but covers most of the DAGS, DOH, DOD, DOT, Judiciary, Agriculture, Public Libraries, and DNLR facilities. For the mentioned State departments, unless any response to the "Energy Survey Form" inquiry was obtained, the DAGS 2001 building square footage data was used in the benchmarking analysis. The "Energy Survey Form" inquiry is described in Section 3.6. The DAGS 2001 State facility square footage area is listed in Appendix 5.0.

3.6. Energy Survey Forms

An "Energy Survey Form" was developed as part of this benchmarking study to collect specific information on the Large State Facilities on Oahu that would particularly aid in developing the ECM Benchmarking analysis. The type of information sought in this "Energy Survey Form" included building occupied square footage area, attached parking area square footage (if applicable), building operation hours, occupancy rate, number of personal computers, information on building lighting, information on building air conditioning, building envelope, renovations history and future energy retrofit plans. A copy of the "Energy Survey Form" is presented in Appendix 6.0.

The developed survey form was distributed to the State departments in Oahu that occupied or operated any of the identified Large State Facilities. These State Departments that were asked to participate in the survey included DAGS, DBEDT, DOE K12, UH Manoa, Community Colleges, DOD, DOH, DOT, PSD, and JUDICIARY. During the development of this report and benchmarking analysis, we have received responses only from DAGS on several of their large facilities.

3.7. UH Manoa ECM Benchmarking Spreadsheet Analysis

An ECM benchmarking analysis was conducted for the UH Manoa Campus in 2004. The ECM benchmarking spreadsheets were developed based on detailed energy audit reports for one third of the total building space area on the campus for various energy conservation opportunities. The detailed analysis of the feasible ECMs that were evaluated in approximately 44 of the buildings were extrapolated campus-wide. Other less frequently occurring ECMs were simply added up to represent the entire campus. The electricity cost savings and construction cost indexes for each ECM were used as the base criteria in developing the projections for the ECM benchmarking for all of the State facilities.

4.0 BENCHMARKING ENERGY ANALYSIS

This benchmarking study uses the same building classification by building size method used in the "Hawaii State Facility Energy Upgrade Analysis and Performance Contracting Potential Phase I and Phase II Reports." One difference in the approach was that this study considers the State facilities on Oahu only, whereas the aforementioned study was developed for State-wide facilities. The Oahu State facilities were categorized as large, medium and small size facilities. The large size facilities were the ones with 1,000,000 kWh per year or more in electrical consumption. The medium size facilities used less than 1,000,000 kWh per year electricity but had more that $50,000 in electrical billing costs per year. The small size facilities were basically the rest of the State facilities on Oahu which had less than $50,000 electrical billing costs per year.

The large State facilities on Oahu listed in Table 4 were extracted from an original list developed in 2002 for the facility upgrade analysis discussed in 3.4 and Appendix 4.1. HECO provided billing histories for the large facilities included in the original list for calendar years 2003 and 2004 which are presented in Appendix 2.0. For this study, the 2004 billing history was used to analyze large state facilities. The resulting electrical billing summary is presented in Table 2.

When Table 2 in this analysis is compared with Table 4 in Appendix 4.1, one can observe that not all large facilities listed in Appendix 4.1 for Oahu are included in Table 2. There are two reasons for this. One, some of the State accounts were closed over the past three years. Two, in some facilities, energy usage dropped below the 1,000,000 kWh reported in the original 2002 data and were consequently excluded from the current Table 2. In addition, the HCDCH facilities listed under DBEDT are now listed under DHS (Department of Human Services).

TABLE 2: STATE LARGE FACILITIES ON OAHU ELECTRICITY CONSUMPTION SUMMARY FOR YEAR 2004

ACCOUNT NUMBER	AGENCY	FACILITY LOCATION	RATE SCHEDULE	TARIFF CODE	NUMBER READINGS	ANNUAL KWH	ANNUAL $ COST	INFORMATION AVAILABLE AUDIT TYPE
8800-6839-077	SOH DAGS	400 S HOTEL ST (STATE CAPITOL)	PS5	1	12	6,126,000	$790,618.00	
8819-2839-079	SOH DAGS	919 ALA MOANA BLVD (AAFES)	J3	1	12	2,243,000	$297,353.00	
8820-4007-075	SOH DAGS	1390 MILLER ST (QUEEN LILIOLULANI)	J3	1	12	2,534,000	$333,361.00	Walkthrough Survey
8820-5318-076	SOH DAGS	1151 PUNCHBOWL ST (KALANIMOKU)	PS5	1	12	7,037,400	$877,507.00	
8820-5319-075	SOH DAGS	1250 PUNCHBOWL ST (KINAU HALE)	J	1	12	1,631,200	$222,814.00	Walkthrough Survey
8824-3048-076	SOH DAGS	235 S BERETANIA ST (OFFICE TOWER)	J	1	12	2,502,400	$337,136.00	
8824-4189-078	SOH DAGS	250 S HOTEL ST (NO. 1-DISTRICT BLDG)	J	1	12	2,567,040	$321,188.00	
8824-4781-075	SOH DAGS	465 S KING ST (KEKUANAO'A BLDG)	J	1	12	1,471,760	$196,359.00	Walkthrough Survey
8824-8557-076	SOH DAGS	830 PUNCHBOWL ST (OFFICE BLDG #2)	J	1	12	4,174,800	$558,214.00	Walkthrough Survey
9800-1977-002	SOH DAGS	601 KAMOKILA BV (KAKUHEIWA KAPOLEI)	J	1	12	3,050,400	$408,107.00	
8823-4938-076	SOH DAGS	99500 SALT LAKE BV (STADIUM AUTHORITY)	J3	1	20	3,416,400	$532,406.00	
TOTAL	SOH DAGS LARGE FACILITIES				11 Facilities	36,754,400	$4,875,063.00	
9600-5614-003	SOH DBEDT	1777 KAPIOLANI BV (HCC)	PS	1	12	7,894,200	$1,129,227.00	
TOTAL	SOH DBEDT CONVENTION CENTER LARGE FACILITIES				1 Facilities	7,894,200	$1,129,227.00	
8819-5909-075	SOH DHS HCDCH	1541 KALAKAUA AV (HCDCH)	PP3	1	12	1,985,500	$240,419.00	
8823-1584-076	SOH DHS HCDCH	99132 KOHOMUA ST (HCDCH)	PP3	1	12	2,579,400	$329,819.00	
9400-2851-001	SOH DHS HCDCH	1545 LINAPUNI ST #BLDG B (HCDCH HHA)	J	1	12	1,318,640	$164,363.00	
9400-2852-001	SOH DHS HCDCH	1475 LINAPUNI ST #BLDG (HCDCH HHA)	J	1	12	1,337,920	$165,635.00	
TOTAL	SOH HUMAN SERVICE LARGE FACILITIES				4 Facilities	7,221,460	$900,236.00	
8811-6162-076	SOH DOD	3949 DIAMOND HEAD RD	J	1	12	1,305,200	$168,418.00	
TOTAL	SOH DODEFENSE LARGE FACILITIES				1 Facility	1,305,200	$168,418.00	
0000-3209-004	SOH DOE	915007 KAPOLEI PKWY	J	1	12	3,609,200	$484,320.00	
0100-2579-004	SOH DOE	46155 KAMEHAMEHA HY	J	1	11	1,210,080	$173,242.00	
0100-2966-002	SOH DOE	91884 FT WEAVER RD	J	1	29	2,049,120	$278,670.00	
8801-3223-078	SOH DOE	2460 WAIMANO HOME RD (PEARL CITY HIGH)	J3	1	12	1,636,200	$223,823.00	
8803-0106-077	SOH DOE	89980 NANAKULI AV (NANAKULI HIGH & INTER)	J3	1	12	1,482,000	$207,595.00	
8803-9117-078	SOH DOE	85271 FARRINGTON HY (WAIANAE HIGH)	J	1	12	1,313,280	$179,640.00	
8806-1340-077	SOH DOE	951200 MEHEULA PARKWAY(MILILANI HIGH)	J3	1	12	1,695,600	$236,818.00	
8809-2020-077	SOH DOE	45386 KANEOHE BAY DR (CASTLE HIGH)	J3	1	58	1,314,000	$177,772.00	
8809-6595-077	SOH DOE	760 ILIAINA ST (KALAHEO)	J	1	12	1,094,240	$155,445.00	
8811-3369-078	SOH DOE	511 LUNALILO HOME RD (KAISER HIGH)	J3	1	24	1,470,000	$203,849.00	
8812-7930-077	SOH DOE	4680 KALANIANAOLE HY (KALANI HIGH)	J	1	36	566,240	$72,239.00	
8814-6868-077	SOH DOE	2705 KAIMUKI AVE (KAIMUKI HIGH)	J3	1	24	2,203,600	$291,705.00	
8818-8260-078	SOH DOE	1120 NEHOA ST (ROOSEVELT HIGH)	J	1	24	1,165,800	$163,478.00	
8819-7510-077	SOH DOE	1039 S KING ST (MCKINLEY HIGH)	J	1	23	2,401,600	$331,155.00	
8822-5334-078	SOH DOE	1185 ALA NAPUNANI ST (MOANALUA HIGH)	J	1	47	1,750,000	$242,024.00	
9600-2562-003	SOH DOE	911561 KEAUNUI RD HOLOMUA ELEMENTARY)	J	1	12	1,657,440	$230,333.00	
9800-2018-003	SOH DOE	951140 LEHIWA DR (MILILANI INTERMED)	J	1	12	2,364,800	$327,725.00	
9900-0148-003	SOH DOE	915335 KAPOLEI PKWY (KAPOLEI MID SCH)	J	1	12	2,094,000	$282,619.00	
8820-3139-077	SOH HSPLS	478 S KING ST (HAWAII STATE LIBRARY)	J	1	12	1,171,440	$170,141.00	
TOTAL	SOT DOEDUCATION LARGE FACILITIES				19 Facilities	32,248,640	$4,432,593.00	

TABLE 2: STATE LARGE FACILITIES ON OAHU ELECTRICITY CONSUMPTION SUMMARY FOR YEAR 2004

ACCOUNT NUMBER	AGENCY	FACILITY LOCATION	RATE SCHEDULE	TARIFF CODE	NUMBER READINGS	ANNUAL KWH	ANNUAL $ COST	INFORMATION AVAILABLE AUDIT TYPE
8808-7404-076	SOH DOH	45747 KEAAHALA RD (HAWAII STATE HOSP)	PP3	1	12	4,632,000	$541,435.00	
8808-7405-076	SOH DOH	45633 KEAAHALA RD	J3	1	12	1,395,000	$175,222.00	
8813-6833-076	SOH DOH	3627 KILAUEA AV (ADMIN SRVC OFF)	J	1	12	1,578,480	$217,135.00	
8813-6841-075	SOH DOH	3675 KILAUEA AV	PP3	1	12	2,982,800	$371,246.00	
8821-2602-075	SOH DOH	1103 HALA DR (MALUHIA HOSP)	PP3	1	12	2,486,400	$299,056.00	
9300-8875-002	SOH DOH	2725 WAIMANO HOME RD (ADMIN OFF)	PS	1	12	6,845,400	$817,416.00	
TOTAL	SOH DOHEALTH LARGE FACILITIES				6 Facilities	19,920,080	$2,421,510.00	
8803-9993-076	SOH PSD	94560 KAMEHAMEHA HY (WAIAWA CORR FAC)	J3	1	12	1,233,000	$155,458.00	
8823-3657-076	SOH PSD	5100 MOANALUA RD	J	1	12	1,355,280	$165,624.00	
8823-3672-076	SOH PSD	99902 MOANALUA RD (HALAWA PRISON)	PS	1	12	5,097,000	$617,725.00	
8823-8291-076	SOH PSD	2199 KAMEHAMEHA HY (OCCC & HSE CORR)	PP3	1	12	6,849,600	$794,028.00	
9300-5247-002	SOH PSD	42477 KALANIANAOLE HY	J	1	12	1,781,120	$215,668.00	
TOTAL	SOH DEPT OF PUBLIC SAFETY LARGE FACILITIES				5 Facilities	16,316,000	$1,948,503.00	
8819-9076-075	SOH DOT-OFFICE	869 PUNCHBOWL ST (TRANSPORTATION)	J	1	24	1,247,520	$166,588.00	
0000-3507-002	SOH DOT - AIR DIV	40 PIER (KAPALAMA MIL RES)	J	1	12	1,391,400	$187,393.00	
8800-6352-076	SOH DOT - AIR DIV	302 RODGERS BV #344 (IAB VAULT "B")	PP3	1	12	12,936,000	$1,453,504.00	
8800-6359-076	SOH DOT - AIR DIV	302 RODGERS BV #342 (SVC CRT VLT "C")	PP3	1	12	7,236,000	$803,431.00	
8800-6365-075	SOH DOT - AIR DIV	302 RODGERS BV #336 (OST VLT "N")	PP3	1	12	16,932,000	$1,905,754.00	
8800-6353-076	SOH DOT - AIR DIV	304 RODGERS BV #360 (EWA VLT "1E")	PP3	1	12	4,196,000	$476,875.00	
8800-6356-075	SOH DOT - AIR DIV	300 RODGERS BV (COMM TERM ELEC)	J3	1	12	1,203,600	$142,471.00	
8800-6357-075	SOH DOT - AIR DIV	300 RODGERS BV #355 (OSPARK VLT "A")	J4	1	12	1,484,720	$172,975.00	
8800-6358-076	SOH DOT - AIR DIV	301 RODGERS BV #A (DIA HD EXT)	PP3	1	12	12,616,800	$1,396,833.00	
8800-6364-076	SOH DOT - AIR DIV	301 RODGERS BV (CEN CONC VLT "Y")	PP3	1	12	5,695,200	$675,038.00	
8800-6360-075	SOH DOT - AIR DIV	303 RODGERS BV #373 (DIA HD VLT "1D")	PP3	1	11	7,653,000	$868,980.00	
9201-0482-002	SOH DOT - AIR DIV	3651 AOLELE ST (EWA CHILLER PLT)	PP3	1	12	12,184,800	$1,408,012.00	
9300-0115-002	SOH DOT - AIR DIV	3650 AOLELE ST (NEW INTERISLE TERM)	PS	1	12	12,043,200	$1,364,261.00	
9300-4842-002	SOH DOT - AIR DIV	3661 AOLELE ST (EWA CONC GATES)	PP3	1	12	2,638,800	$303,361.00	
8811-0340-076	SOH DOT HWY DIV	2 PALI HY (PRIMECO & ST LTS)	J3	1	11	788,640	$102,437.00	
8824-9624-058	SOH DOT HWY DIV	0 WILSON TUNNEL	J3	1	12	1,372,800	$169,706.00	
9400-4323-001	SOH DOT HWY DIV	0 H-3 TUNNEL HAIKU IB PORTAL (HE INT)	J3	1	12	3,984,000	$592,960.00	
TOTAL	SOH DOTRANSPORTATION LARGE FACILITIES				17 Facilities	105,604,480	$12,190,579.00	
8819-9077-077	SOH JUDICIARY	777 PUNCHBOWL ST (KAAHUMANU HALE)	PS	1	12	3,946,000	$495,030.00	Lighting Energy Audit
8824-2360-078	SOH JUDICIARY	1111 ALAKEA ST (KAUIKEAOULI DIS CT 1ST C)	PS	1	12	4,683,000	$580,849.00	Lighting Energy Audit
8824-4780-075	SOH JUDICIARY	417 S KING ST (ALIIOLANE HALE)	J5	1	12	1,639,680	$213,991.00	Lighting Energy Audit
TOTAL	SOH JUDICIARY LARGE FACILITIES				3 Facilities	10,268,680	$1,289,870.00	
8815-4443-075	UH MANOA	2777 KALAKAUA AV (WAIKIKI AQUARIUM)	J	1	12	1,326,960	$161,912.00	
8816-2154-076	UH MANOA	1701 EAST WEST RD (FACILITIES MGMT)	PP3	1	12	129,300,000	$14,786,615.00	
8817-7690-076	UH MANOA	2680 WOODLAWN DR (ASTRONOMY FAC)	PP3	1	12	2,315,400	$273,801.00	Detailed Energy Audit Exists
9800-2426-001	UH MANOA	46007 LILIPUNA RD (HIMB)	J	1	12	1,658,000	$202,771.00	
TOTAL	UH MANOA LARGE FACILITIES				5 Facilities	134,600,360	$15,425,099.00	

TABLE 2: STATE LARGE FACILITIES ON OAHU ELECTRICITY CONSUMPTION SUMMARY FOR YEAR 2004

ACCOUNT NUMBER	AGENCY	FACILITY LOCATION	RATE SCHEDULE	TARIFF CODE	NUMBER READINGS	ANNUAL KWH	ANNUAL $ COST	INFORMATION AVAILABLE AUDIT TYPE
8801-5005-075	UH COMM COLL	96045 ALAIKE ST (LEEWARD)	PP3	1	12	5,752,800	$730,218.00	
8814-8544-076	UH COMM COLL	655 MAKAPUU AV (KAPIOLANI BUSINESS)	J3	1	12	8,069,400	$1,049,593.00	
8823-6252-075	UH COMM COLL	874 DILLINGHAM BV (HONOLULU)	PP3	1	36	5,006,000	$663,227.00	
9500-5803-001	UH COMM COLL	45720 KEAAHALA RD (HALE IMILOA)	PS	1	12	5,650,200	$692,104.00	
TOTAL	UH COMMUNITY COLLEGES LARGE FACILITIES				4 Facilities	24,478,400	$3,135,142.00	
TOTAL	OAHU SOH LARGE FACILITIES				76 Facilities	396,611,900	$47,916,240.00	
TOTAL	ALL OAHU SOH FACILITIES					557,654,688	$71,372,318	

71.1 % Electricity Used by the Large Facilities Listed in This Table

LEGEND:

ACCTNUM	UTILITY ACCOUNT NUMBER FOR FACILITY	
ANNUAL DATA	TARIFF CODE 1 THROUGH 5 CONSUMPTION DATA FOR 1-JUL-01 THROUGH 30-JUN-02 TARIFF CODE 6 CONSUMPTION DATA FOR 1-JAN-01 THROUGH 31-DEC-01	
LARGE FACILITY	ELECTRICAL CONSUMPTION EXCEEDS ONE MILLION KWH PER YEAR	
NBRMTH	NUMBER OF MONTHS METERED, IF NUMBER EXCEEDS 12 THEN THERE IS MORE THAN ONE METER.	
RATESCH	UTILITY RATE SCHEDULE	
TARCDE	TARIFF CODE	1 = HAWAIIAN ELECTRIC COMPANY

The benchmarking data used in this study did not include the electrical consumption history for medium and small size buildings. Instead, the medium size State facilities electrical consumption for year 2004 was estimated in proportion to the medium size facility electrical consumption table in Appendix 4.1 and State of Hawaii electrical consumption by State Agencies and percentage electricity consumed listed in Appendix 4.0. The small size facilities energy use was prorated and adjusted to maintain a consistent tally between the large facility and total facility electrical energy use for each year. Table 3 is a summary of the electrical use history for large, medium and small size facilities on Oahu in 2002 by State Agency, composed from the data in Appendix 4.0 and Appendix 4.1. By using the electricity percentages listed in Table 2 and engineering assumptions to account for the changes in electrical usage from 2002 to 2004, Table 4 was developed. The large facilities electrical use summary in the Table 4 is a summary of Table 2 for each State agency. The electrical use summary for the medium and small facilities in the estimates is developed by the procedure described above.

Additional useful information derived from the comparison of Table 4 with the 2004 trend and the Table 3 with the 2002 trend is the total electrical use comparison and electricity cost variation from 2002 to 2004. In 2002, the State facilities used 531,823,960 kWh of electricity and paid $58,540,841 in electrical costs, which corresponded to roughly 11.0 cents per kWh. In 2003, the State facilities used 556,768,580 kWh of electricity and paid $67,245,821 in electrical costs, which corresponds to roughly 12.1 cents per kWh. In 2004, the State facilities used 557,654,688 kWh of electricity and paid $71,372,318 in electricity, which corresponds to roughly 12.8 cents per kWh. This increase in the electrical energy cost was due primarily to the escalation in the fuel charge adjustment due to the rising cost for oil. The fuel charge adjustment from 2002 to 2004 has increased electrical energy cost per kWh by approximately 16%. Table 5 summarizes the electrical consumption trend and associated electrical costs for 2002, 2003 and 2004. Additionally Figure 1 and Figure 2 represent the electrical

energy use and cost trends graphically. Both the table and the graphics demonstrate that if the fuel charge adjustment continues to increase, dramatic energy savings will need to be achieved in order to keep the electrical costs under control.

TABLE 3: STATE OF HAWAII FACILITIES ON OAHU ELECTRICITY CONSUMPTION SUMMARY IN YEAR 2002 FOR LARGE, MEDIUM AND SMALL SIZE FACILITY DISTRIBUTION*

	LARGE FACILITIES/METERS				MEDIUM FACILITIES/METERS				SMALL FACILITIES/METERS				TOTAL ALL FACILITIES		
AGENCY	**NUMBER OF METERS**	**ANNUAL KWH**	**ANNUAL $ COST**	**% OF TOTAL**	**NUMBER OF METERS**	**ANNUAL KWH**	**ANNUAL $ COST**	**% OF TOTAL**	**NUMBER OF METERS**	**ANNUAL KWH**	**ANNUAL $ COST**	**% OF TOTAL**	**ANNUAL KWH**	**ANNUAL $ COST**	**% OF TOTAL**
DAGS	13	40,360,322	$ 4,624,631	7.589	5	3,670,240	$ 452,238	0.690	NA	2,659,120	$ 347,421	0.500	46,689,682	$ 5,424,289	8.779
DHS	4	6,442,000	$ 677,769	1.211	10	7,538,620	$ 835,059	1.418	NA	1,329,560	$ 173,710	0.250	15,310,180	$ 1,686,538	2.879
DBEDT	2	8,578,720	$ 1,034,996	1.613	1	292,704	$ 53,344	0.055	NA	1,329,560	$ 173,710	0.250	10,200,984	$ 1,262,051	1.918
DOD	1	1,530,720	$ 174,952	0.288	3	2,125,230	$ 252,462	0.400	NA	1,063,648	$ 138,968	0.200	4,719,598	$ 566,382	0.887
DOE	22	35,971,687	$ 4,448,686	6.764	51	29,667,631	$ 3,920,196	5.578	NA	50,241,410	$ 6,564,163	9.447	115,880,728	$ 14,933,046	21.789
DOH	6	18,676,400	$ 1,950,040	3.512	2	1,197,840	$ 154,440	0.225	NA	9,041,007	$ 1,181,230	1.700	28,915,247	$ 3,285,710	5.437
PSD	5	16,323,760	$ 1,656,646	3.069	-	-	-	-	NA	-	-	-	16,323,760	$ 1,656,646	3.069
DOT	16	107,466,560	$ 10,603,048	20.207	6	3,639,395	$ 435,903	0.684	NA	3,722,768	$ 486,389	0.700	114,828,723	$ 11,525,339	21.591
JUDICIARY	3	10,919,040	$ 1,174,803	2.053	1	541,040	$ 62,385	0.102	NA	531,824	$ 69,484	0.100	11,991,904	$ 1,306,672	2.255
UH MANOA	6	128,751,650	$ 12,376,756	24.209	4	3,015,848	$ 346,118	0.567	NA	531,824	$ 69,484	0.100	132,299,322	$ 12,792,358	24.877
UH COMMUNITY COLLEGES	4	21,649,590	$ 2,422,470	4.071	1	439,440	$ 56,286	0.083	NA	521,687	$ 68,160	0.098	22,610,717	$ 2,546,916	4.252
AGRICULTURE	-	-	-		1	657,155	$ 83,764	0.124	NA	1,170,013	$ 152,865	0.220	1,827,168	$ 236,629	0.344
PUBLIC TV	-	-	-		1	998,800	$ 112,715	0.188	NA	-	-	0.000	998,800	$ 112,715	0.188
OTHER**										9,227,146	$ 1,205,549	1.735	9,227,146	$ 1,205,549	1.735
OAHU SOH Sub-TOTAL	82	396,670,449	$ 41,144,797	74.587	86	53,783,943	$ 6,764,910	10.113	NA	81,369,568	$ 10,631,134	15.300	531,823,960	$58,540,841	100.000

* LARGE SIZE FACILITY: ELECTRICITY CONSUMPTION 1,000,000 kWh OR MORE
MEDIUM SIZE FACILITY: ELECTRICITY CONSUMPTION LESS THAN 1,000,000 kWh OR ELECTRICITY BILL EQUAL OR MORE THAN $50,000
SMALL SIZE FACILITY: ELECTRICITY BILL LESS THAN $50,000

** OTHER:
Department of Attorney General
Department of Hawaiian Homelands
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department pf Agriculture
Other Facilities

ALL OAHU SOH FACILITIES TOTAL 531,823,960 kWh
$ 58,540,841 $ Cost,

LARGE FACILITIES 75 % of total electricity consumed
MEDUIM FACILITIES 10 % of total electricity consumed
SMALL FACILITIES 15 % of total electricity consumed

TABLE 4: STATE OF HAWAII FACILITIES ON OAHU ELECTRICITY CONSUMPTION SUMMARY IN YEAR 2004 FOR LARGE, MEDIUM AND SMALL SIZE FACILITY DISTRIBUTION*

	LARGE FACILITIES/METERS				MEDIUM FACILITIES/METERS				SMALL FACILITIES/METERS				TOTAL ALL FACILITIES		
AGENCY	**NUMBER OF METERS**	**ANNUAL KWH**	**ANNUAL $ COST**	**% OF TOTAL**	**NUMBER OF METERS**	**ANNUAL KWH**	**ANNUAL $ COST**	**% OF TOTAL**	**NUMBER OF METERS**	**ANNUAL KWH**	**ANNUAL $ COST**	**% OF TOTAL**	**ANNUAL KWH**	**ANNUAL $ COST**	**% OF TOTAL**
DAGS	12	36,754,400	$ 4,875,063	6.591	NA	3,847,817	$ 560,439	0.690	NA	3,903,583	$ 568,562	0.700	44,505,800	$ 6,004,064	7.981
DHS	4	7,221,460	$ 900,236	1.295	NA	4,143,374	$ 603,488	0.743	NA	1,505,668	$ 219,302	0.270	12,870,502	$ 1,723,026	2.308
DBEDT	1	7,894,200	$ 1,129,227	1.416	NA	4,070,879	$ 592,929	0.730	NA	1,840,260	$ 268,036	0.330	13,805,340	$ 1,990,192	2.476
DOD	1	1,305,200	$ 168,418	0.234	NA	2,230,619	$ 324,892	0.400	NA	1,394,137	$ 203,058	0.250	4,929,955	$ 696,368	0.884
DOE	19	32,248,640	$ 4,432,593	5.783	NA	31,105,978	$ 4,530,624	5.578	NA	54,912,257	$ 7,998,037	9.847	118,266,876	$ 16,961,254	21.208
DOH	6	19,920,080	$ 2,421,510	3.572	NA	1,254,723	$ 182,752	0.225	NA	13,941,367	$ 2,030,577	2.500	35,116,170	$ 4,634,839	6.297
PSD	5	16,316,000	$ 1,948,503	2.926	NA	-	-	-	NA	-	-	-	16,316,000	$ 1,948,503	2.926
DOT	16	105,604,480	$ 12,190,579	18.937	NA	3,814,358	$ 555,566	0.684	NA	5,018,892	$ 731,008	0.900	114,437,730	$ 13,477,153	20.521
JUDICIARY	3	10,268,680	$ 1,289,870	1.841	NA	568,808	$ 82,848	0.102	NA	1,115,309	$ 162,446	0.200	11,952,797	$ 1,535,164	2.143
UH MANOA	5	134,600,360	$ 15,425,099	24.137	NA	3,161,902	$ 460,535	0.567	NA	1,115,309	$ 162,446	0.200	138,877,571	$ 16,048,080	24.904
UH COMMUNITY COLLEGES	4	24,478,400	$ 3,135,142	4.390	NA	451,700	$ 65,791	0.081	NA	1,115,309	$ 162,446	0.200	26,045,410	$ 3,363,379	4.671
AGRICULTURE	-	-	-		NA	691,492	$ 100,717	0.124	NA	1,226,840	$ 178,691	0.220	1,918,332	$ 279,407	0.344
PUBLIC TV	-	-	-		NA	1,046,082	$ 152,363	0.188	NA	-	-	0.000	1,046,082	$ 152,363	0.188
OTHER**										17,566,123	$ 2,558,527	3.150	17,566,123	$ 2,558,527	3.150
OAHU SOH Sub-TOTAL	76	396,611,900	$ 47,916,240	71.121	NA	56,387,733	$ 8,212,942	10.112	NA	104,655,055	$ 15,243,136	18.767	557,654,689	$71,372,318	100.000

* LARGE SIZE FACILITY: ELECTRICITY CONSUMPTION 1,000,000 kWh OR MORE
MEDIUM SIZE FACILITY: ELECTRICITY CONSUMPTION LESS THAN 1,000,000 kWh OR ELECTRICITY BILL EQUAL OR MORE THAN $50,000
SMALL SIZE FACILITY: ELECTRICITY BILL LESS THAN $50,000

** OTHER:
Department of Attorney General
Department of Hawaiian Homelands
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department pf Agriculture
Other Facilities

ALL OAHU SOH FACILITIES TOTAL 557,654,688 kWh
$ 71,372,318 $ Cost,

LARGE FACILITIES 71 % of total electricity consumed
MEDUIM FACILITIES 10 % of total electricity consumed
SMALL FACILITIES 19 % of total electricity consumed

Table 5: State Facilities on Oahu Electricity Consumption and Cost for the years 2002, 2003 and 2004.

YEAR	Electricity Consumption per Year	Electricity Cost per Year
2002	531,823,960	$58,540,841
2003	556,768,580	$67,245,821
2004	557,654,688	$71,372,318

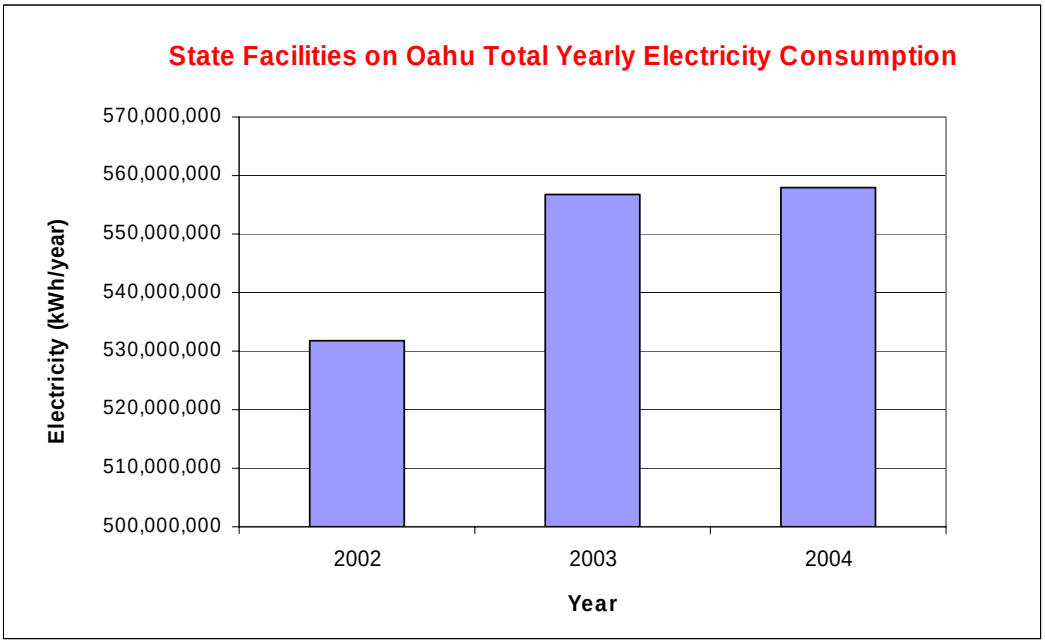

Figure 1: State Facilities on Oahu Electricity Consumption Trend in the past three years.

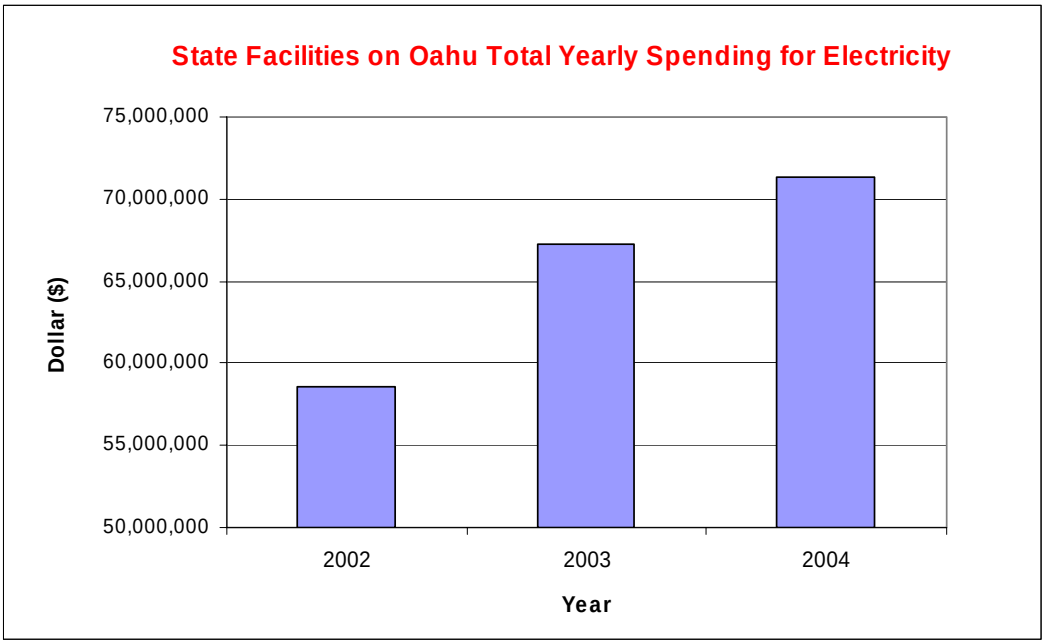

Figure 2: State Facilities on Oahu Electricity Cost Trend in the past three years.

The next step in the benchmarking analysis for the State facilities on Oahu was the development of a benchmarking baseline. Three data categories were identified in the study:

1) Large facilities with known building square footage and yearly electricity consumption,

2) Large facilities with unknown building square footage and known yearly electricity consumption,

3) Medium and small size facilities with no building square footage or yearly electricity consumption data.

Section 4.1 describes in detail the benchmarking baseline development process.

Each agency can be represented by a dominant building type by occupancy. Table 6 lists each State agency with its dominating building occupancy type.

Table 6: State Agencies with Dominating Building Occupancy Type

Description		Building Occupancy Type
DAGS	Department of Accounting and General Service	Office
JUDICIARY	Department of Judiciary	Office
DBEDT	Department of Business Economic Development and Tourism	Convention Center
DHS	Department of Human Service	Office
DOD	Department of Defense	Office
OTHER	Other Departments	Office
DOE K-12	Department of Education	Office/Classroom
UH MANOA	Department of Education University of Hawaii at Manoa	Office/Classroom
COMM COLL	Department of Education Community Colleges	Office/Classroom
DOH	Department of Health	Hospital
PSD	Department of Public Safety	Correction Facility
DOT	Department of Transportation	Airport, Highway

The benchmarking energy analysis was then developed in two stages: a baseline spreadsheet analysis and an estimated electrical use distribution by type of building equipment (air conditioning, lighting and miscellaneous equipment). The methodology followed in both analyses is described in the following sections.

4.1 Baseline Spreadsheet Analysis

A baseline spreadsheet analysis was developed based on the available benchmarking data (mainly for large facilities) and may be found in Appendix 8.0. The spreadsheet information included the basic building data including, Building Name, Building Type, Operating Schedule, Year Built, Area (sq.ft.), Energy Use, Energy Savings projects in the Past Eight Years. Under Energy Use, kWh/year, kWh/sq.ft/year, $year, and $sq.ft./year are listed. Under Energy Savings Projects in the Past Eight Years, Lighting, Water Heating, Motor Replacement, Space Cooling Retrofits, Custom Rebate are listed. The rebate

information was especially useful to predict the age of the existing building lighting and air conditioning equipment and to account for already implemented energy conservation measures. This information is also used in the ECM Benchmarking analysis in Section 5.

The baseline spreadsheet was grouped by each State agency, under three categories of benchmarking data. The first category data were for large buildings with known yearly electricity use and known building occupied area in square feet. The second category data was for large buildings with known yearly electricity use and unknown building occupied area in square feet. The square feet area was estimated by the ratio between the yearly electricity consumption and the average kWh per square feet per year calculated for the large buildings in the first category. The third category data was for the medium and small size facilities. The only available data for this category was the percentage of electricity use estimated in Table 4 (the Table 4 was discusses in Section 4). By using the average kWh per square feet year calculated for the large buildings in the first category and the percentage electricity from Table 4, the facility square feet area was also similarly calculated for the medium and small size buildings. Appendix 8.0 documents this baseline spreadsheet analysis. The "Energy Savings Projects in the Past Eight Years" columns are the rebate summary for each rebate type applied to all facilities for an agency.

Few agencies, including DBEDT, DHS, DOE K-12, PSD, Community College, had no facility square footage, or first category data, as described above. For those agencies, the baseline spreadsheet was developed by using the average kWh per square feet per year data from another agency that was closest in the type of building use. The DBEDT and DHS kWh per square feet per year was considered to be the same as JUDICIARY. The ratio of the HECO reported yearly electricity consumption over the assumed kWh per square feet per year data produced the DBEDT and DHS buildings square footage area estimates. Similarly, the Community Colleges kWh per square feet per year was considered to be same as

that for UH Manoa. For DOE K-12, an assumed value of 15 kWh per square feet per year was used, since this agency has less air conditioning consumption when compared to fully air conditioned facilities. A similar analysis was carried for the DOPublic Safety that used the 15 kWh per square feet per year criteria due to its lower quantity of air conditioned space. The "OTHER" State facility category in Appendix 8.0 used the overall average kWh per square feet per year criteria in estimating the facility square footage area.

Building operational hours is another important factor in the benchmarking analysis. However, the available building operational data consisted of only the six large DAGS buildings, which was not sufficient for benchmarking. Therefore, in the study no detailed analysis was made that would account for the effect of building operational hours on a building's energy consumption.

The building floor area and electrical energy use distribution by State agencies are illustrated in charts in Figure 3 and Figure 4. As can be followed from the charts, UH Manoa Campus, DOE K12 schools and DOT are the highest energy consumers with the largest facility areas. The building floor area and yearly electricity usage by square foot for each agency and States-wide percentage electricity usage are documented in Table 7. The Table is ordered from the largest to the smallest in terms of electrical consumption.

Electrical energy use distribution by occupancy type, including office, school (including all university, community college and K-12 facilities), hospital, airport, highway & harbor and correction facilities, for Oahu are illustrated in Figure 5. This figure shows that approximately 50% of State facilities are classroom/office type facilities, representing the DOE's K - 12 schools, the community colleges and the University of Hawaii at Manoa.

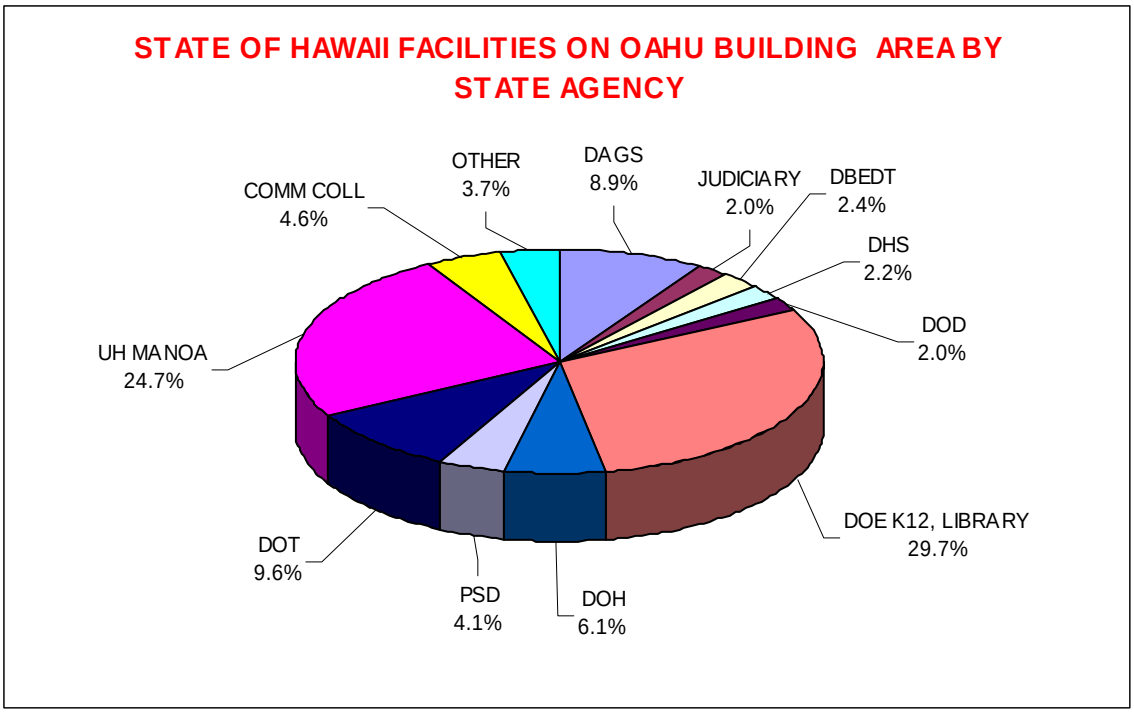

Figure 3: State of Hawaii Facilities on Oahu Building Square Feet Area by State Agency.

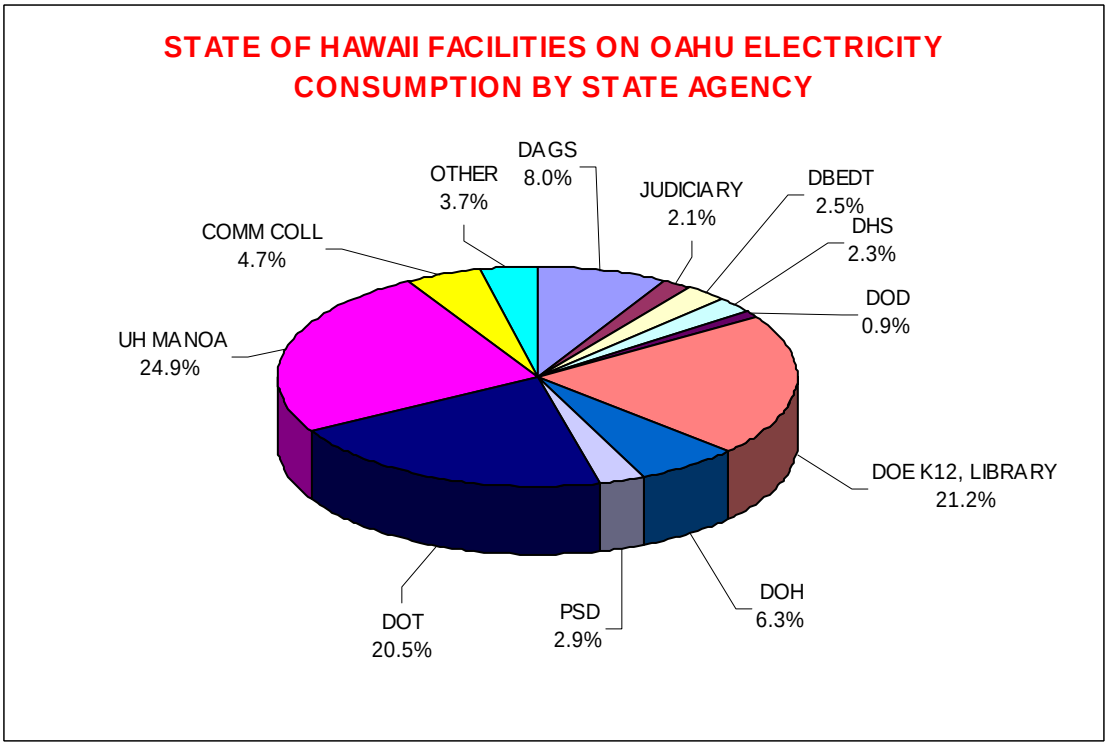

Figure 4: State of Hawaii Facilities on Oahu Building Electricity Consumption by State Agency.

Table 7: State of Hawaii Facilities on Oahu Building Floor Area and Yearly Electricity Use as of 2004

State Agency	Total Occupied Building Space (sq.ft.)	% Total Building Space (sq.ft.)	Total Building Electricity (kWh/year)	Total Building Electricity Use per square foot (kWh/sq.ft.-year)	% of Total Energy Use	% Energy Use per % Building Area
UH MANOA	6,509,109	24.7	138,877,571	21.3	24.9	1.0
DOE K12, PUBLIC LIBRARY	7,829,650	29.7	118,266,875	15.1	21.2	0.7
DOT	2,540,917	9.6	114,437,730	45.0	20.5	2.1
DAGS	2,337,265	8.9	44,505,800	19.0	8.0	0.9
DOH	1,606,870	6.1	35,116,171	21.9	6.3	1.0
COMM COLL	1,220,733	4.6	26,045,410	21.3	4.7	1.0
PSD	1,087,733	4.1	16,316,000	15.0	2.9	0.7
OTHER	971,907	3.7	20,530,537	21.1	3.7	1.0
DBEDT	620,043	2.4	13,805,340	22.3	2.5	1.1
DHS	578,056	2.2	12,870,502	22.3	2.3	1.1
JUDICIARY	536,839	2.0	11,952,797	22.3	2.1	1.1
DOD	528,803	2.0	4,929,956	9.3	0.9	0.5
TOTAL	26,367,927	100	557,654,688	21.1	100	

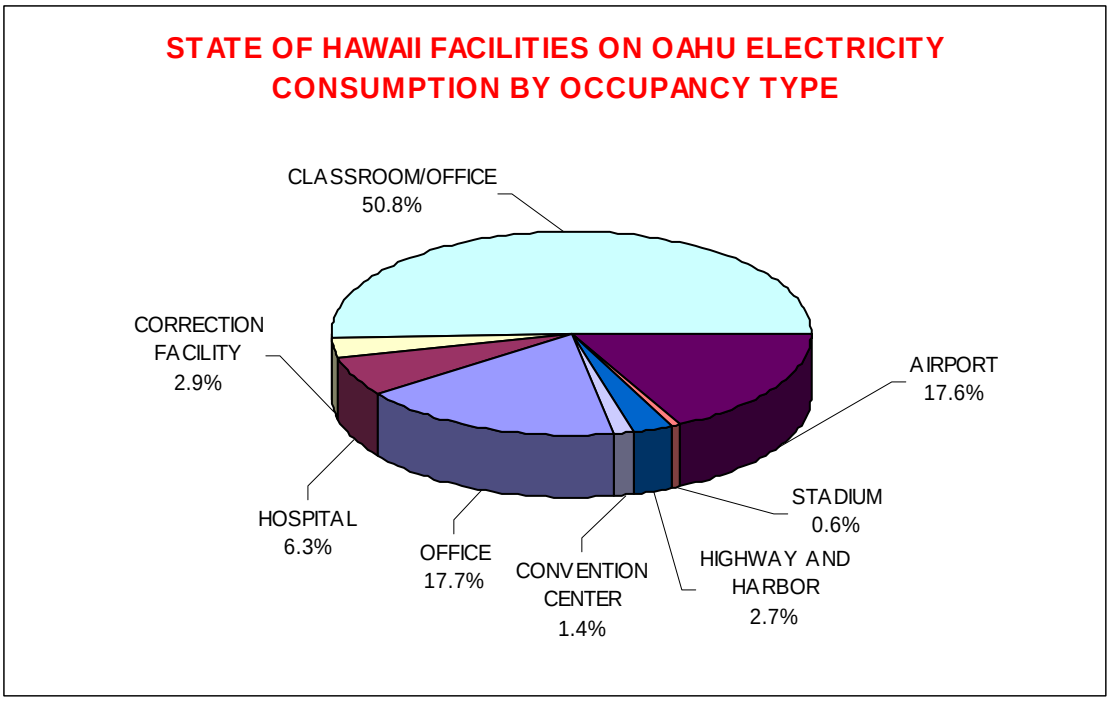

Figure 5: State Facilities on Oahu Electricity Consumption Percentage by Building Occupancy.

4.2 Baseline Electricity Distribution by End Use

In this phase of the analysis, a spreadsheet was developed that estimated the electricity usage by HVAC, lighting and miscellaneous utility load types (Appendix 9.0). Among the existing available data categories, the "UH Manoa Energy Benchmarking Study" data, explained in Section 3.1 was utilized extensively in this analysis. The UH Manoa Campus makes up approximately 24 percent of the State facilities square footage area, and approximately 25 percent of the electricity usage by the State on Oahu. Furthermore, 44 large buildings in the campus that comprise approximately one third of the campus occupied building square footage area were energy audited. Additional walkthrough audits were conducted on the remaining buildings of the UH Manoa Campus buildings as part of the energy benchmarking study, to help determine the electrical utilization characteristics of those buildings. In summary, the UH Manoa Campus energy

benchmarking data was well documented, and there were only a few extrapolations and projections that were utilized in the benchmarking study. Figure 6 shows a pie-chart of the UH Manoa electricity consumption percentage by utility types: 52% of campus electricity is used for air conditioning; 30% for lighting; and 18% for miscellaneous use**;** including computers, coffee makers, elevators and other building equipment not covered under the lighting or air conditioning categories.

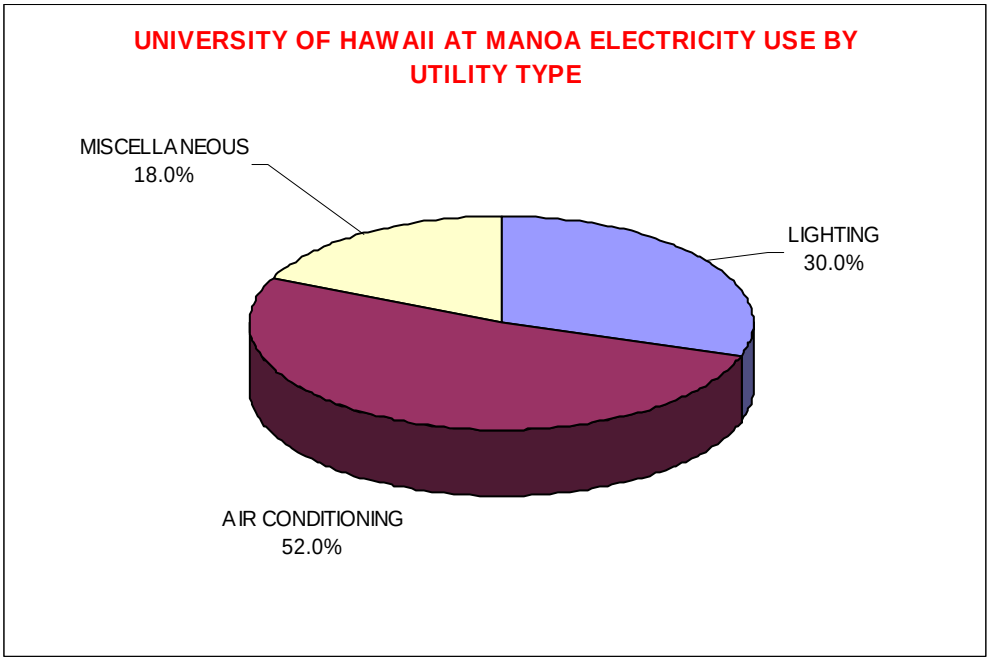

Figure 6: UH Manoa Electricity Consumption Percentage by Utility.

Based on this evaluation, the UH Manoa electricity distribution by utility type was adapted for this study for the applicable buildings in the remaining State facilities on Oahu that were assumed to be fully air conditioned. Other buildings with limited air conditioning such as DOE classroom buildings, DOD storage rooms, PSD correction facilities were not categorized by the UH Manoa electricity distribution by utility type. Instead, the electrical usage distribution in these buildings was estimated by the engineering judgment. The end use utility percentages were defined as 20% air conditioning, 62% to lighting and 18% to

miscellaneous use. Appendix 9.0 documents the baseline electricity distribution by utility type for each State agency. .

The resulting electrical energy use distribution by utilization category, including air conditioning, lighting and miscellaneous equipment for all facilities on Oahu is illustrated in Figure 7. Air conditioning is the highest electricity consuming category (44%) among the three categories. Figure 8 shows the adjusted electrical consumption percentage for DOE, DOD and PSD facilities indicating that lighting is the highest electrical energy consuming category (62%).

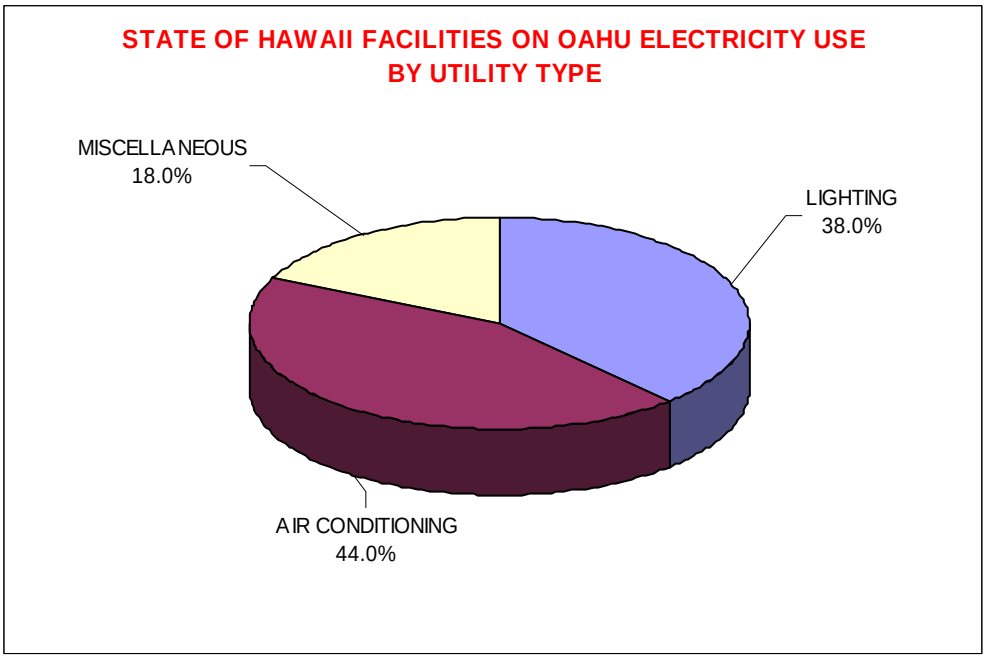

Figure 7: State Facilities on Oahu Electricity Consumption Percentage by Utility.

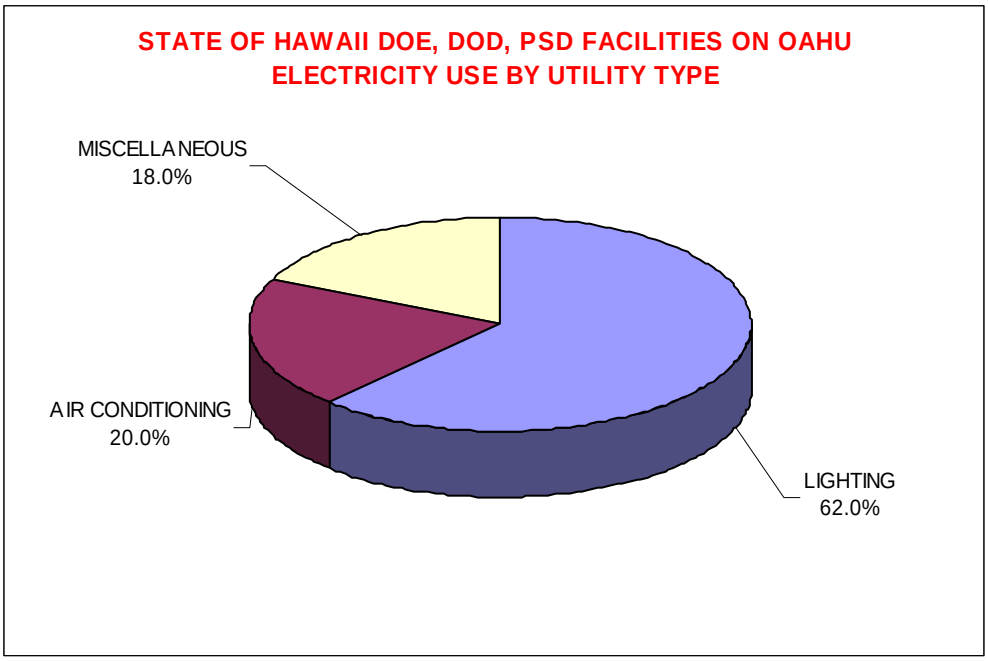

Figure 8: DOE, DOD, and PSD Consumption Percentage by Utility

5.0 BENCHMARKING ENERGY CONSERVATION MEASURES (ECM's)

The ECM benchmarking analysis was developed for all State departments and occupancy categories. The analysis utilized the baseline material in Section 4.0: Benchmarking Energy Analysis. Three additional data sources were used in the ECM benchmarking analysis: 1) Appendix 2.1: HECO Rebate History for All State Facilities on Oahu from 1997 through 2004, 2) Appendix 3.0: Summary of Existing Energy Audit/Survey Results Presented in "Task 1-a-1 Report", and 3) Appendix 7.0: UH Manoa Campus Energy Benchmarking Study ECM Spreadsheet Analysis.

The process of developing the State facilities on Oahu ECM benchmark spreadsheets and analysis is described as follows: First, the "Baseline Benchmark Analysis by End Use Electricity" spreadsheet in Appendix 9.0 was utilized as the initial spreadsheets. Second, the ECMs considered at the UH Manoa Energy Benchmarking Study (Appendix 7.0) were evaluated for their applicability to the State facilities. All of the identified ECMs in the UH Manoa study were found applicable to the other State facilities in this study. However several ECM's were clustered under a category identified as "ECM: Other due to their applications being too specific and/or their lower energy savings impact. A total of eleven ECMs were identified as being applicable to all of the State facilities on Oahu. Table 8 shows the comparison of the ECMs utilized in the State Facilities on Oahu Benchmarking versus the UH Manoa Benchmarking.

Table 8: List of ECMs Used for UH Manoa and List of ECMs Identified for State Facilities

State Facilities on Oahu Benchmarking Study List of ECMs		UH Manoa Benchmarking Study List of ECMs	
ECM-I	Interior and exterior lighting Replacement	ECM-I	Interior and exterior lighting Replacement
ECM-II	LED Exit Sign Installation	ECM-II	LED Exit Sign Installation
ECM-III	Reflective Solar Window Tinting	ECM-III	Reflective Solar Window Tinting
ECM-IV	Chiller Retrofits	ECM-IV	Chiller Retrofits
ECM-V	Variable Speed Drive Utilization	ECM-V	Variable Speed Drive Utilization
ECM-VI	Motor Replacement with High Efficiency Motors	ECM-VI	Other (Building Specific Applications)
ECM-VII	Waste Heat Recovery System	ECM-VII	Motor Replacement with High Efficiency Motors
ECM-VIII	Packaged Air Conditioning Unit Replacement	ECM-VIII	Waste Heat Recovery System
ECM-IX	Facility Management Systems (FMS) Installation	ECM-IX	Packaged Air Conditioning Unit Replacement
ECM-X	Insulation Installation	ECM-X	Facility Management Systems (FMS) Installation
ECM-XI	Other (Convert Constant Volume to VAV System, Repair VAV Control System, Install Outside Air CO2 Sensor Controlling Outside Air Dampers, UH Study ECM: VI Other)	ECM-XI	Insulation Installation
		ECM-XII	Convert Constant Volume to VAV System
		ECM-XIII	Repair VAV Control System
		ECM-XIV	Install Outside Air CO2 Sensor Controlling Outside Air Dampers

The third step in the analysis was estimating the ECM savings for each State facility. All three additional data sources mentioned earlier (Appendix 2.1, Appendix 3.0, Appendix 7.0) were used in development of the ECM energy savings, implementation cost and payback period estimates. Initially, the energy savings, cost savings and retrofit construction cost per square feet for each UH Manoa ECM were determined from the Appendix 7.0. Those are shown in Table 9 for an easy reference. In the table, "Energy Cost Savings ($/sq.ft.-year)" represents dollar savings due to electrical energy savings, which is obtained by multiplying the "Energy Savings (kWh/sf.ft.-year) with $0.089 electricity cost per kWh for UH Manoa in 2003. The "Equipment & Maintenance Cost Savings

($/sq.ft.-year) represent maintenance savings due to equipment replacement and cost savings due to the favorable lifecycle of the new equipment.

Table 9: UH Manoa Benchmarking Energy Savings and Construction Cost Data per Square Feet for each ECM Evaluated in the Study

ECM	Energy Savings kWh/sf.ft.-year	Energy Cost Savings $/sq.ft.-year	Equipment & Maintenance Cost Savings $/sq.ft.-year	Energy Equipment & Maintenance Cost Savings $/sq.ft.-year	Estimated Construction Cost $/sq.ft.-year
ECM I: Interior and Exterior Lighting Replacement	0.805	0.072	0.015	0.087	0.651
ECM II: LED Exit Sign Installation	0.055	0.005	0.014	0.019	0.071
ECM III: Reflecive Solar Window Tinting	0.139	0.012	0.000	0.012	0.092
ECM IV: Chiller Retrofits	1.092	0.097	0.006	0.103	0.652
ECM V: Variable Speed Drive Utilization	0.480	0.043	0.004	0.047	0.240
ECM VI: Other ECM	0.051	0.005	0.000	0.005	0.065
ECM VII: High Efficiency Motor Retrofits	0.105	0.009	0.000	0.009	0.076
ECM VIII: Waste Heat Recovery System	0.041	0.004	0.000	0.004	0.010
ECM IX: Packaged Air Conditioning Replacement	0.076	0.007	0.001	0.007	0.068
ECM X: Facility Management System (FMS) Installation	0.434	0.039	0.003	0.042	0.056
ECM XI: Insulation Installation	0.205	0.018	0.002	0.020	0.160
ECM XII: Convert Constant Volume to VAV System	0.032	0.003	0.000	0.003	0.025
ECM XIII: Repair VAV Control System	0.015	0.001	0.001	0.003	0.035
ECM XIV: Install Outside Air CO2 Sensors	0.073	0.007	0.002	0.008	0.044

NOTES:

1- Total UH sq.ft. area evaluated in the ECM Analysis	2,393,739
2- Total UH Electricity Use in Fiscal Year 2003, kWh	139,765,181
3- Total UH Electricity Cost in Fiscal Year 2003, $	12,449,044
4- Electricity Cost Per kWh, $ per kWh	0.089

Based on the ECM savings and cost per square feet summary in Table 9, an initial ECM energy savings, cost savings and retrofit construction cost per square foot table was developed for the State Facilities. This is shown in Table 10. The process of developing the Table 10 is described as follows:

1- Energy Savings per kWh per sq.ft.-year is taken from Table 9.
2- Energy Cost Savings per sq.ft.-year is calculated by multiplying (energy savings kWh per sq.ft.-year) with ($ 0.128 Electricity Cost Per kWh for State Facilities in 2004).
3- Equipment & Maintenance Cost Savings ($/sq.ft.-year) is taken from Table 9, and used for ECM I and ECM II, since they were relatively high when compared to the other ECMs.
4- Equipment & Maintenance Cost Savings ($/sq.ft.-year) of other ECMs were considered zero for simplicity since they were relatively small when compared to energy cost savings ($/sq.ft.-year) in Table 9.
5- Energy Equipment & Maintenance Cost Savings ($/sq.ft.-year) is the sum of energy cost savings and equipment & maintenance cost savings.
6- Estimated Construction Cost ($/sq.ft.-year) is taken from the Table 9 and increased by 20% to reflect recent cost increases in the construction industry.
7- Several ECMs which were originally evaluated under separate categories in the UH Benchmarking Study were consolidated under a single ECM (ECM IX:Other) in this study due to their less frequent occurrence and lower savings when compared to the rest of the ECMs.

Table 10: Initial State Facilities Benchmarking Energy Savings and Construction Cost per Square Feet for each ECM Adapted from UH Benchmarking Study

ECM	Energy Savings kWh/sf.ft.-year	Energy Cost Savings $/sq.ft.-year	Equipment & Maintenance Cost Savings $/sq.ft.-year	Energy Equipment & Maintenance Cost Savings $/sq.ft.-year	Estimated Construction Cost $/sq.ft.-year
ECM I: Interior and Exterior Lighting Replacement	0.805	0.103	0.015	0.118	0.781
ECM II: LED Exit Sign Installation	0.055	0.007	0.014	0.021	0.085
ECM III: Reflecive Solar Window Tinting	0.139	0.018	0	0.018	0.110
ECM IV: Chiller Retrofits	1.092	0.140	0	0.140	0.782
ECM V: Variable Speed Drive Utilization	0.480	0.061	0	0.061	0.288
ECM VI: High Efficiency Motor Retrofits	0.105	0.013	0	0.013	0.092
ECM VII: Waste Heat Recovery System	0.041	0.005	0	0.005	0.012
ECM VIII: Packaged Air Conditioning Replacement	0.076	0.010	0	0.010	0.081
ECM IX: Facility Management System (FMS) Installation	0.434	0.056	0	0.056	0.067
ECM X: Insulation Installation	0.205	0.026	0	0.026	0.192
ECM XI: Other (Convert Constant Volume to VAV System, Repair VAV Control System, Install Outside Air CO2 Sensors, Other)	0.171	0.022	0	0.022	0.204

NOTES:

1- Total State Electricity Use in Fiscal Year 2003, kWh	557,654,688	
2- Total State Electricity Cost in Fiscal Year 2003, $	71,372,318	
3- Electricity Cost Per kWh, $ per kWh	0.128	
4- State vs UH Electricity Cost Ratio	1.437	
5- Construction Cost Increase Rate	20	%

Please note that as the Table 10 title implies, energy savings, cost and construction cost indexes determined in the table are not the final rates used in the State Facilities Benchmarking spreadsheet analysis. Another consideration/ process had to be integrated into the analysis before finalizing the ECM indexes.

This process had to do with integrating the HECO rebate history for all State facilities on Oahu from 1997 through 2004 in Appendix 2.1 and the summary of existing energy audit/survey results included in Appendix 3.0.

The energy audit/surveys summary in Appendix 3.0 included the four DAGS buildings, one DBEDT buildings and all Judiciary buildings in Oahu that were previously audited and some equipment was already retrofitted with one or more energy conserving alternatives. The already completed ECM retrofits were listed in the summary in Appendix 3.0. For those buildings listed in Appendix 3.0 with a specific ECM already implemented, no further savings potentials were considered for that particular ECM in the benchmarking spreadsheet analysis in the current study. A similar approach was followed for the HECO rebate data in Appendix 2.1. If HECO already awarded a building with a rebate due to an ECM retrofit, no further savings potentials were considered for that particular ECM in the benchmarking spreadsheet analysis in the current study. The "Energy Savings" column in the ECM benchmarking spreadsheet was marked zero for buildings that had already implemented the particular ECM.

Bu using the Appendix 8.0 Baseline Benchmarking Analysis Electricity Use, integrated with Appendix 2.1 and Appendix 3.0, Table 11 was developed. The table lists total State facilities on Oahu square footage considered for a particular ECM (all State facilities square footage in this benchmarking study), the total square footage State facility area with an already implemented ECM, and their ratio.

Table 11: State Facilities Already Implemented ECM Square Footage Area Ratios

ECM	Total sq.ft. Area of ECM Analysis	Total sq.ft. Area Already ECO Retrofitted	ECMs Retrofitted Area Ratio %
ECM I: Interior and Exterior Lighting Replacement	26,367,927	4,704,136	17.8
ECM II: LED Exit Sign Installation	26,367,927	0	0.0
ECM III: Reflecive Solar Window Tinting	26,367,927	0	0.0
ECM IV: Chiller Retrofits	26,367,927	14,075,234	53.4
ECM V: Variable Speed Drive Utilization	26,367,927	14,075,234	53.4
ECM VI: High Efficiency Motor Retrofits	26,367,927	7,545,954	28.6
ECM VII: Waste Heat Recovery System	26,367,927	9,249,962	35.1
ECM VIII: Packaged Air Conditioning Replacement	26,367,927	14,420,273	54.7
ECM IX: Facility Management System (FMS) Installation	26,367,927	0	0.0
ECM X: Insulation Installation	26,367,927	0	0.0
ECM XI: Other (Convert Constant Volume to VAV System, Repair VAV Control System, Install Outside Air CO2 Sensors, Other)	26,367,927	12,385,730	47.0

The final step for determining the ECM benchmarking savings and cost analysis is the integration of the Table 11 information into the initial benchmarking indexes calculated and presented in Table 10. The original UH Manoa ECM benchmarking indexes, listed in Table 9, were developed by dividing the total energy savings for each ECM with total square foot building area considered in the benchmarking analysis (It is important to mention here that UH ECM benchmarking considers only the buildings that were energy audited previously, and the square footage used in the benchmarking also were compiled of those buildings with energy audits). During the energy audits and the benchmarking study, the UH also had buildings that were already ECM retrofitted. However,

the UH benchmarking did not separate those buildings that were already retrofitted with a particular ECM, as in the case of the State of Hawaii Benchmarking Study for Oahu facilities. Instead, the UH benchmarking study added up already estimated ECM savings and associated construction costs for the buildings that were energy audited, and extrapolated the results for all the buildings considered in the benchmarking study. This difference in both benchmarking studies necessitated a final adjustment in the Table 10 ECM savings and cost indexes. The Energy Savings kWh/sq.ft.-year column and the Estimated Construction Cost $/sq.ft.-year column in Table 10 had to be increased by the percentage given in the Table 11 ECM Retrofitted Area Percentage column. The effect of this final adjustment process, while not noticeable in the total ECM savings and associated cost, was to develop as accurately as possible a representation of already implemented ECMs (indicated with zeros in the energy savings columns in the benchmarking spreadsheet) and potential ECMs for each building and agency in the benchmarking study.

The final State facilities benchmarking energy savings and construction cost indexes used in the current benchmarking study are listed in Table 12. The benchmarking spreadsheet analysis developed by the final indexes in Table 12 is documented in Appendix 10.0.

Table 12: Final State Facilities Benchmarking Energy Savings and Construction Cost per Square Feet for each ECM

ECO	Energy Savings kWh/sf.ft.-year	Energy Cost Savings $/sq.ft.-year	Equipment & Maintenance Cost Savings $/sq.ft.-year	Energy Equipment & Maintenance Cost Savings $/sq.ft.-year	Estimated Construction Cost $/sq.ft.-year
ECM I: Interior and Exterior Lighting Replacement	0.949	0.121	0.015	0.136	0.921
ECM II: LED Exit Sign Installation	0.055	0.007	0.014	0.021	0.085
ECM III: Reflecive Solar Window Tinting	0.139	0.018	0	0.018	0.110
ECM IV: Chiller Retrofits	1.675	0.214	0	0.214	1.200 (2.860)
ECM V: Variable Speed Drive Utilization	0.736	0.094	0	0.094	0.442
ECM VI: High Efficiency Motor Retrofits	0.135	0.017	0	0.017	0.118
ECM VII: Waste Heat Recovery System	0.055	0.007	0	0.007	0.016
ECM VIII: Packaged Air Conditioning Replacement	0.118	0.015	0	0.015	0.126
ECM IX: Facility Management System (FMS) Installation	0.434	0.056	0	0.056	0.067
ECM X: Insulation Installation	0.205	0.026	0	0.026	0.192
ECM XI: Other (Convert Constant Volume to VAV System, Repair VAV Control System, Install Outside Air CO2 Sensors, Other)	0.252	0.032	0	0.032	0.299

A final adjustment was made on Table 12 for ECM IV: Chiller Retrofit on the estimated construction cost per square feet per year. When we evaluated the construction cost by $1.20 per square feet per year for a chiller replacement, it yielded a simple payback period of 5.6 years. From our experience and previous energy analysis, this appeared to be a rather low payback projection for chiller retrofit projects. In order to provide a realistic and conservative construction cost estimate, the total tonnage cooling load for each building was estimated using rule of thumb sizing. The estimated corresponding total construction cost was then

developed and converted to cost per square foot. A chiller retrofit cost of $2.80 per sq.ft is what was finally used in the chiller retrofit ECM analysis.

5.1 State Facilities on Oahu Energy Conservation Measure Benchmarking Results

Based on the results of the benchmarking study, an approximate estimate of ECM savings and associated cost was determined for each State facility on Oahu. A total of eleven ECMs were identified that would produce energy savings with a payback period of less than 15 years. Based on our analysis, implementation of these Energy Conservation Measures (ECMs) for all State buildings on Oahu would result in an estimated electrical savings of 78,906,487 kWh per year, or $10,735,823 per year. The estimated construction cost for implementation of the evaluated ECMs is $78,256,206 which would result in a payback of about 7.3 years. This would correspond to roughly a 14% reduction in electrical consumption for the State facilities on Oahu. Table 13 summarizes the eleven ECMs by their potential energy savings, payback periods and savings percentages. Please note that future electrical cost increases were not factored into the ECM payback estimates. If future electrical cost increases are considered, the payback periods may be shortened considerably. Table 14 shows the same ECMs listed in Table 13 ordered by their energy savings potential from highest to lowest, including their associated electrical energy saving potential by percentage of total energy use. According to our analysis, ECM-IV Chiller Retrofits has the highest savings potential, 3.69%, followed by ECM-I Interior and Exterior Lighting Replacement with a 3.06% savings potential, ECM-IX Facility Management Systems (FMS) Installation with a 2.05% savings potential, and ECM-V Variable Drive Utilization with a 2.03% savings potential.

Table 13: Energy Conservation Measures and Potential Energy Savings as of 2004

Description		Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($/year)	Estimated Construction Cost ($)	Simple Payback (Year)
ECM-I	Interior and exterior lighting Replacement	17,048,460	3.1	2,439,780	16,522,333	6.8
ECM-II	LED Exit Sign Installation	1,450,236	0.3	553,726	2,241,274	4.0
ECM-III	Reflective Solar Window Tinting	3,665,623	0.7	474,623	2,900,472	6.1
ECM-IV	Chiller Retrofits	20,590,260	3.7	2,630,636	35,157,100	13.4
ECM-V	Variable Speed Drive Utilization	11,300,314	2.0	1,451,133	6,777,101	4.7
ECM-VI	Motor Replacement with High Efficiency Motors	2,396,361	0.4	301,764	2,094,597	6.9
ECM-VII	Waste Heat Recovery System	944,912	0.2	121,538	273,887	2.3
ECM-VIII	Packaged Air Conditioning Unit Replacement	1,253,157	0.2	159,300	1,338,116	8.4
ECM-IX	Facility Management Systems (FMS) Installation	11,443,680	2.1	1,476,604	1,766,651	1.2
ECM-X	Insulation Installation	5,415,477	1.0	685,556	5,062,642	7.4
ECM-XI	Other	3,398,489	0.6	441,154	4,122,034	9.3
	Totals	78,906,487	14.2	10,735,823	78,256,206	7.3

Table 14: Energy Conservation Measures as of 2004, Sorted by Energy Savings Impact

Description		Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($/year)	Estimated Construction Cost ($)	Simple Payback (year)
ECM-IV	Chiller Retrofits	20,590,260	3.7	2,630,636	35,157,100	13.4
ECM-I	Interior and exterior lighting Replacement	17,048,460	3.1	2,439,780	16,522,333	6.8
ECM-IX	Facility Management Systems (FMS) Installation	11,443,680	2.1	1,476,604	1,766,651	1.2
ECM-V	Variable Speed Drive Utilization	11,300.314	2.0	1,451,133	6,777,101	4.7
ECM-X	Insulation Installation	5,415,477	1.0	685,556	5,062,642	7.4
ECM-III	Reflective Solar Window Tinting	3,665,623	0.7	474,623	2,900,472	6.1
ECM-XI	Other	3,398,489	0.6	441,154	4,122,034	9.3
ECM-VI	Motor Replacement with High Efficiency Motors	2,396,361	0.4	301,764	2,094,597	6.9
ECM-II	LED Exit Sign Installation	1,450,236	0.3	553,726	2,241,274	4.0
ECM-VIII	Packaged Air Conditioning Unit Replacement	1,253,157	0.2	159,300	1,338,116	8.4
ECM-VII	Waste Heat Recovery System	944,912	0.2	121,538	273,887	2.3
	Totals	78,906,487	14.2	10,735,823	78,256,206	7.3

Table 15 summarizes the ECM's for each State agency. The Table 15 information would be useful if the ECM implementation is prioritized by State agency. According to the analysis, if all ECMs were implemented at the UH Manoa facility, 5.2% of the State's electrical costs may be saved on Oahu. Similarly, implementation of the ECM's at the DOE's K - 12 Facilities and Public Libraries would result in a 2.1 % reduction in the State total electrical costs.

Table 15: Energy Conservation Measures and Implementation Cost Breakdown by State Agency, as of 2004.

Building Occupancy	Estimated Energy Savings (kWh/year)	Estimated Energy Savings (kWh/sq.ft. -year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($)	Estimated Energy Cost Savings Per sq.ft. ($)	Estimated Construction Cost ($)	Estimated Const. Cost per sq.ft. ($)	Simple Payback (Year)
UH MANOA	28,952,157	4.5	5.2	3,891,630	0.60	31,906,080	4.9	8.2
DOE K12, PUBLIC LIBRARY	11,895,402	1.5	2.1	1,690,408	0.22	8,751,558	1.1	5.2
DOT	9,389,534	3.7	1.7	1,247,371	0.50	10,320,922	4.1	8.3
DAGS	8,195,882	3.5	1.5	1,117,324	0.48	8,482,092	3.4	5.5
DOH	5,787,111	3.6	1.0	780,453	0.49	5,711,629	3.6	7.3
COMM COLL	3,779,793	3.1	0.7	501,856	0.41	4,107,137	3.4	8.2
OTHER*	2,742,918	2.8	0.5	379,141	0.39	2,015,736	2.1	5.3
PSD	2,213,972	2.0	0.4	314,355	0.29	1,761,040	1.6	5.6
DHS	2,218,352	3.8	0.4	300,422	0.52	2,182,610	3.9	7.4
DOD	1,745,860	3.3	0.3	238,626	0.45	1,521,358	2.9	6.4
DBEDT	1,153,667	1.9	0.2	160,331	0.26	823,276	1.3	5.1
JUDICIARY	831,839	1.6	0.2	113,905	0.21	672,767	1.3	5.9
TOTAL	78,906,487	3.0	14.2	10,735,823	0.41	78,256,206	3.0	7.3

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture

6.0 CONCLUSIONS AND RECOMMENDATIONS

This energy benchmarking study characterizes electrical energy usage for State facilities on Oahu. The data is presented for each State agency, and by end usage distribution. This report also identifies the Energy Conservation Measures (ECMs) that would help to reduce the State's electrical consumption and quantifies their energy savings potential and associated construction cost for their implementation.

If the 11 ECMs, identified and evaluated in Section 5, are implemented, the State can save up to 14.2% in electricity in Oahu. With those savings, the State facilities' electrical usage may be reduced from 21.1 kWh per sf per year down to 18.2 kWh per sf per year. Table 13 in Section 5 presents the energy savings potential and the associated implementation cost and simple payback period for each ECM. The information in this table is re-ordered by their estimated energy savings in Table 16, by simple payback period in Table 17, and by estimated cConstruction costs in Table 18. As can be followed from the tables, while the ECM IV: Chiller Retrofits may yield the highest electricity savings (up to 3.7%), its construction cost and simple payback period (13.4 years) is also the highest. On the other hand, ECM IX: Facility Management System (FMS) Installation offers up to 2.1% in toal energy savings with relatively low construction costs and a 1.2 years simple payback period. These tables can thus be used to prioritize decisions on implementing energy efficiency measures in these facilities.

Table 15 in Section 5 that illustrates the ECM analysis summary for each agency, is also re-ordered by building square footage in Table 19, by estimated energy savings in Table 20, by estimated energy cost savings in Table 21, by estimated construction cost in Table 12, and by simple payback period in Table 23. From the Tables, the UH Manoa and DOT offer the largest savings, but also require the largest construction costs and have relatively higher simple payback periods. On

the other hand, DOE K-12 Schools and DAGS offer comparable energy savings with lower construction costs and simple payback periods.

The data presented in this study is a good indicator that there is a large potential for energy savings in the State facilities on Oahu. The analysis also suggests that the cost to implement the recommended ECMs will be cost effective since the simple payback periods for all of the ECMs at all of the State agencies on Oahu are less than 15 years. Therefore, we do recommend that the energy conservation measures identified for each State agency be pursued.

During the time this study was conducted, some information was not available. Such information included building square footage for DOE K-12 schools, UH Community Colleges, PSD facilities, and DHS facilities. Air conditioning status for the DOE K-12 schools and PSD facilities were also not available. Data on building operational hours and building age were not available for most of agencies and facilities. The "Energy Survey Form" developed and distributed to the State agencies were not completed by most of the agencies except DAGS and DOT Airport Facilities. While DAGS surveys were included in this analysis, the DOT Airport surveys were obtained just before the completion of this study, and was therefore it was not included in the analysis. When the listed data becomes available, this study may further be refined. Additionally, walkthrough energy audits for the large State facilities would tremendously improve the study.

Performance contracting is one possible contracting mechanism for the State to utilize in order to implement the identified ECMs in this study. If performance contracting is utilized, we recommend that the performance contracts be pursued for each State agency separately. All ECMs should be included in the performance contracts as single package. Based on this benchmarking analysis, the combined simple payback period for the implementation of all ECMs at each agency is less than 10 years. This suggests that each agency's facilities are an acceptable candidate for performance contracting, since the energy cost savings

realized over the life of the contract will cover the costs for the ECM improvements. The priority for performance contracting should be given to the agencies with lower payback periods. Table 24 lists the State agencies recommended for performance contracting with the priority ordered from lowest simple payback period to the highest. In the list, performance contracts have already been utilized at some of DAGS, DBEDT, DOD, and JUDICIARY facilities to implement selected ECMs. The Table 24 has already factored the previous implemented ECM savings into the analysis, and includes the additional projected savings and cost savings for only the facilities that have not used performance contracting and ECMs that have not yet been implemented.

Table 16: Energy Conservation Measures as of 2004, Sorted by Estimated Energy Savings

Description		Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($/year)	Estimated Construction Cost ($)	Simple Payback (year)
ECM-IV	Chiller Retrofits	20,590,260	3.7	2,630,636	35,157,100	13.4
ECM-I	Interior and exterior lighting Replacement	17,048,460	3.1	2,439,780	16,522,333	6.8
ECM-IX	Facility Management Systems (FMS) Installation	11,443,680	2.1	1,476,604	1,766,651	1.2
ECM-V	Variable Speed Drive Utilization	11,300.314	2.0	1,451,133	6,777,101	4.7
ECM-X	Insulation Installation	5,415,477	1.0	685,556	5,062,642	7.4
ECM-III	Reflective Solar Window Tinting	3,665,623	0.7	474,623	2,900,472	6.1
ECM-XI	Other	3,398,489	0.6	441,154	4,122,034	9.3
ECM-VI	Motor Replacement with High Efficiency Motors	2,396,361	0.4	301,764	2,094,597	6.9
ECM-II	LED Exit Sign Installation	1,450,236	0.3	553,726	2,241,274	4.0
ECM-VIII	Packaged Air Conditioning Unit Replacement	1,253,157	0.2	159,300	1,338,116	8.4
ECM-VII	Waste Heat Recovery System	944,912	0.2	121,538	273,887	2.3
	Totals	78,906,487	14.2	10,735,823	78,256,206	7.3

Table 17: Energy Conservation Measures as of 2004, Sorted by Simple Payback Year

Description		Simple Payback (year)	Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($/year)	Estimated Construction Cost ($)
ECM-IX	Facility Management Systems (FMS) Installation	1.2	11,443,680	2.1	1,476,604	1,766,651
ECM-VII	Waste Heat Recovery System	2.3	944,912	0.2	121,538	273,887
ECM-II	LED Exit Sign Installation	4.0	1,450,236	0.3	553,726	2,241,274
ECM-V	Variable Speed Drive Utilization	4.7	11,300.314	2.0	1,451,133	6,777,101
ECM-III	Reflective Solar Window Tinting	6.1	3,665,623	0.7	474,623	2,900,472
ECM-I	Interior and exterior lighting Replacement	6.8	17,048,460	3.1	2,439,780	16,522,333
ECM-VI	Motor Replacement with High Efficiency Motors	6.9	2,396,361	0.4	301,764	2,094,597
ECM-X	Insulation Installation	7.4	5,415,477	1.0	685,556	5,062,642
ECM-VIII	Packaged Air Conditioning Unit Replacement	8.4	1,253,157	0.2	159,300	1,338,116
ECM-XI	Other	9.3	3,398,489	0.6	441,154	4,122,034
ECM-IV	Chiller Retrofits	13.4	20,590,260	3.7	2,630,636	35,157,100
	Totals	7.3	78,906,487	14.2	10,735,823	78,256,206

Table 18: Energy Conservation Measures as of 2004, Sorted by Estimated Construction Cost

Description		Estimated Construction Cost ($)	Estimated Energy Savings (kWh/year)	Estimated Energy Cost Savings ($/year)	Estimated Energy Savings %	Simple Payback (year)
ECM-VII	Waste Heat Recovery System	273,887	944,912	121,538	0.2	2.3
ECM-VIII	Packaged Air Conditioning Unit Replacement	1,338,116	1,253,157	159,300	0.2	8.4
ECM-IX	Facility Management Systems (FMS) Installation	1,766,651	11,443,680	1,476,604	2.1	1.2
ECM-VI	Motor Replacement with High Efficiency Motors	2,094,597	2,396,361	301,764	0.4	6.9
ECM-II	LED Exit Sign Installation	2,241,274	1,450,236	553,726	0.3	4.0
ECM-III	Reflective Solar Window Tinting	2,900,472	3,665,623	474,623	0.7	6.1
ECM-XI	Other	4,122,034	3,398,489	441,154	0.6	9.3
ECM-X	Insulation Installation	5,062,642	5,415,477	685,556	1.0	7.4
ECM-V	Variable Speed Drive Utilization	6,777,101	11,300.314	1,451,133	2.0	4.7
ECM-I	Interior and exterior lighting Replacement	16,522,333	17,048,460	2,439,780	3.1	6.8
ECM-IV	Chiller Retrofits	35,157,100	20,590,260	2,630,636	3.7	13.4
	Totals	78,256,206	78,906,487	10,735,823	14.2	7.3

Table 19: Energy Conservation Measures and Implementation Cost Breakdown by State Agency as of 2004, Sorted by Total Agency Building Square Footage

Building Occupancy	Total Facility Square Footage	Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($)	Electricity Savings Per sq.ft. $	Estimated Construction Cost ($)	Estimated Const. Cost per sq.ft. ($)	Simple Payback (Year)
DOE K12, PUBLIC LIBRARY	7,829,650	11,895,402	2.1	1,690,408	0.22	8,751,558	1.1	5.2
UH MANOA	6,509,109	28,952,157	5.2	3,891,630	0.60	31,906,080	4.9	8.2
DOT	2,540,917	9,389,534	1.7	1,247,371	0.50	10,320,922	4.1	8.3
DAGS	2,337,265	8,195,882	1.5	1,117,324	0.48	8,482,092	3.4	5.5
DOH	1,606,870	5,787,111	1.0	780,453	0.49	5,711,629	3.6	7.3
COMM COLL	1,220,733	3,779,793	0.7	501,856	0.41	4,107,137	3.4	8.2
PSD	1,087,733	2,213,972	0.4	314,355	0.29	1,761,040	1.6	5.6
OTHER*	971,908	2,742,918	0.5	379,141	0.39	2,015,736	2.1	5.3
DHS	578,056	2,218,352	0.4	300,422	0.52	2,182,610	3.9	7.4
DBEDT	620,043	1,153,667	0.2	160,331	0.26	823,276	1.3	5.1
JUDICIARY	536,839	831,839	0.2	113,905	0.21	672,767	1.3	5.9
DOD	528,803	1,745,860	0.3	238,626	0.45	1,521,358	2.9	6.4
TOTAL	26,367,927	78,906,487	14.2	10,735,823	0.41	78,256,206	3.0	7.3

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture

Table 20: Energy Conservation Measures and Implementation Cost Breakdown by State Agency as of 2004, Sorted by Estimated Energy Savings per Year

Building Occupancy	Estimated Energy Savings (kWh/year)	Estimated Energy Savings (kWh/sq.ft. -year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($)	Estimated Energy Cost Savings Per sq.ft. $	Estimated Construction Cost ($)	Estimated Const. Cost per sq.ft. ($)	Simple Payback (Year)
UH MANOA	28,952,157	4.5	5.2	3,891,630	0.60	31,906,080	4.9	8.2
DOE K12, PUBLIC LIBRARY	11,895,402	1.5	2.1	1,690,408	0.22	8,751,558	1.1	5.2
DOT	9,389,534	3.7	1.7	1,247,371	0.50	10,320,922	4.1	8.3
DAGS	8,195,882	3.5	1.5	1,117,324	0.48	8,482,092	3.4	5.5
DOH	5,787,111	3.6	1.0	780,453	0.49	5,711,629	3.6	7.3
COMM COLL	3,779,793	3.1	0.7	501,856	0.41	4,107,137	3.4	8.2
OTHER*	2,742,918	2.8	0.5	379,141	0.39	2,015,736	2.1	5.3
PSD	2,213,972	2.0	0.4	314,355	0.29	1,761,040	1.6	5.6
DHS	2,218,352	3.8	0.4	300,422	0.52	2,182,610	3.9	7.4
DOD	1,745,860	3.3	0.3	238,626	0.45	1,521,358	2.9	6.4
DBEDT	1,153,667	1.9	0.2	160,331	0.26	823,276	1.3	5.1
JUDICIARY	831,839	1.6	0.2	113,905	0.21	672,767	1.3	5.9
TOTAL	78,906,487	3.0	14.2	10,735,823	0.41	78,256,206	3.0	7.3

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture

Table 21: Energy Conservation Measures and Implementation Cost Breakdown by State Agency as of 2004, Sorted by Estimated Energy Cost Savings

Building Occupancy	Estimated Energy Cost Savings ($)	Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Savings (kWh/sq.ft.-year)	Estimated Construction Cost ($)	Estimated Const. Cost per sq.ft. ($)	Simple Payback (Year)
UH MANOA	3,891,630	28,952,157	5.2	0.60	31,906,080	4.9	8.2
DOE K12, PUBLIC LIBRARY	1,690,408	11,895,402	2.1	0.22	8,751,558	1.1	5.2
DOT	1,247,371	9,389,534	1.7	0.50	10,320,922	4.1	8.3
DAGS	1,117,324	8,195,882	1.5	0.48	8,482,092	3.4	5.5
DOH	780,453	5,787,111	1.0	0.49	5,711,629	3.6	7.3
COMM COLL	501,856	3,779,793	0.7	0.41	4,107,137	3.4	8.2
OTHER*	379,141	2,742,918	0.5	0.39	2,015,736	2.1	5.3
PSD	314,355	2,213,972	0.4	0.29	1,761,040	1.6	5.6
DHS	300,422	2,218,352	0.4	0.52	2,182,610	3.9	7.4
DOD	238,626	1,745,860	0.3	0.45	1,521,358	2.9	6.4
DBEDT	160,331	1,153,667	0.2	0.26	823,276	1.3	5.1
JUDICIARY	113,905	831,839	0.2	0.21	672,767	1.3	5.9
TOTAL	10,735,823	78,906,487	14.2	0.41	78,256,206	3.0	7.3

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture

Table 22: Energy Conservation Measures and Implementation Cost Breakdown by State Agency as of 2004, Sorted by Estimated Construction Cost

Building Occupancy	Estimated Construction Cost ($)	Estimated Const. Cost per sq.ft. ($)	Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($)	Estimated Energy Savings (kWh/sq.ft .-year)	Simple Payback (Year)
JUDICIARY	672,767	1.3	831,839	0.2	113,905	0.21	5.9
DBEDT	823,276	1.3	1,153,667	0.2	160,331	0.26	5.1
DOD	1,521,358	2.9	1,745,860	0.3	238,626	0.45	6.4
PSD	1,761,040	1.6	2,213,972	0.4	314,355	0.29	5.6
OTHER*	2,015,736	2.1	2,742,918	0.5	379,141	0.39	5.3
DHS	2,182,610	3.9	2,218,352	0.4	300,422	0.52	7.4
COMM COLL	4,107,137	3.4	3,779,793	0.7	501,856	0.41	8.2
DOH	5,711,629	3.6	5,787,111	1.0	780,453	0.49	7.3
DAGS	8,482,092	3.4	8,195,882	1.5	1,117,324	0.48	5.5
DOE K12, PUBLIC LIBRARY	8,751,558	1.1	11,895,402	2.1	1,690,408	0.22	5.2
DOT	10,320,922	4.1	9,389,534	1.7	1,247,371	0.50	8.3
UH MANOA	31,906,080	4.9	28,952,157	5.2	3,891,630	0.60	8.2
TOTAL	78,256,206	3.0	78,906,487	14.2	10,735,823	0.41	7.3

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture

Table 23: Energy Conservation Measures and Implementation Cost Breakdown by State Agency as of 2004, Sorted by Simple Payback Period

Building Occupancy	Simple Payback (Year)	Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($)	Estimated Energy Savings (kWh/sq.ft .-year)	Estimated Construction Cost ($)	Estimated Const. Cost per sq.ft. ($)
DBEDT	5.1	1,153,667	0.2	160,331	0.26	823,276	1.3
DOE K12, PUBLIC LIBRARY	5.2	11,895,402	2.1	1,690,408	0.22	8,751,558	1.1
OTHER*	5.3	2,742,918	0.5	379,141	0.39	2,015,736	2.1
DAGS	5.5	8,195,882	1.5	1,117,324	0.48	8,482,092	3.4
PSD	5.6	2,213,972	0.4	314,355	0.29	1,761,040	1.6
JUDICIARY	5.9	831,839	0.2	113,905	0.21	672,767	1.3
DOD	6.4	1,745,860	0.3	238,626	0.45	1,521,358	2.9
DOH	7.3	5,787,111	1.0	780,453	0.49	5,711,629	3.6
DHS	7.4	2,218,352	0.4	300,422	0.52	2,182,610	3.9
UH MANOA	8.2	28,952,157	5.2	3,891,630	0.60	31,906,080	4.9
COMM COLL	8.2	3,779,793	0.7	501,856	0.41	4,107,137	3.4
DOT	8.3	9,389,534	1.7	1,247,371	0.50	10,320,922	4.1
TOTAL	7.3	78,906,487	14.2	10,735,823	0.41	78,256,206	3.0

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture

Table 24: List of State Agencies That are Candidates for Performance Contracting

Building Occupancy	Simple Payback (Year)	Estimated Energy Savings (kWh/year)	Estimated Energy Savings %	Estimated Energy Cost Savings ($)	Estimated Construction Cost ($)
DBEDT	5.1	1,153,667	0.2	160,331	823,276
DOE K12, PUBLIC LIBRARY	5.2	11,895,402	2.1	1,690,408	8,751,558
OTHER*	5.3	2,742,918	0.5	379,141	2,015,736
DAGS	5.5	8,195,882	1.5	1,117,324	8,482,092
PSD	5.6	2,213,972	0.4	314,355	1,761,040
JUDICIARY	5.9	831,839	0.2	113,905	672,767
DOD	6.4	1,745,860	0.3	238,626	1,521,358
DOH	7.3	5,787,111	1.0	780,453	5,711,629
DHS	7.4	2,218,352	0.4	300,422	2,182,610
UH MANOA	8.2	28,952,157	5.2	3,891,630	31,906,080
COMM COLL	8.2	3,779,793	0.7	501,856	4,107,137
DOT	8.3	9,389,534	1.7	1,247,371	10,320,922
TOTAL	7.3	78,906,487	14.2	10,735,823	78,256,206

* OTHER: Department of Attorney General
Department of Labor and Industrial Relations
Department of Land and Natural Resources
Department of Hawaiian Homelands
Department of Agriculture